Defence Research and Development Canada
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Stakeholder Analysis for the CF Counter-IED Training Courses

Simon Banbury, Kristina Osgoode, David Unrau, Chelsea Kramer, Jordan Miller
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Contract No.: W7711-09-8153/001/TOR

Contract Scientific Authority:
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Defence R& D Canada
Contract Report
DRDC Toronto CR 2010-059
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Abstract

One of the most challenging activities for a distance education facilitator is to be responsive to student needs and customize the learning experience to the student's individual learning style, help socialize the student to the institution, and keep the learner engaged in spite of the isolated environment. To achieve these goals, mechanisms to improve efficiency and effectiveness for the Canadian Forces (CF) distance learning capability need to be explored. To support these goals, a *Requirement and Stakeholder Analysis for the CF Counter-IED Training Courses* was undertaken to investigate the requirements of stakeholders of the CF IED Disposal (IEDD) Operator Training Course for the development of adaptive learning technology integration and validation plans. Given the high failure rate in the existing IEDD Operator Course, problematic aspects of the course was one of the foci of the Stakeholder Analysis. The discussion with stakeholders focused, in part, on the feasibility of demonstrating the capability of intelligent tutoring technology within the IEDD Operator Course. The report presents the results of the Stakeholder Analysis interviews and recommends the implementation plan for the IEDD Operator Course Intelligent Tutoring System (ITS), in terms of its content and capabilities, and describes the notional architecture of the IEDD ITS in more detail. The report also recommends the evaluation plan for the IEDD Operator Course ITS in terms of the methodology and approximate schedule for activities pertaining to the evaluation of the ITS.

Résumé

L'une des tâches les plus difficiles qui incombe à l'instructeur à distance est de répondre aux besoins de l'apprenant et de personnaliser l'acquisition de connaissances en fonction du style d'apprentissage du stagiaire, d'entretenir la relation entre le stagiaire et l'établissement de formation et de conserver la motivation de l'apprenant malgré son isolement. Pour y parvenir, il faut examiner des moyens d'améliorer la rentabilité et l'efficacité de la capacité d'apprentissage à distance des Forces canadiennes (FC). Dans cette optique, on a entrepris une *Analyse des besoins et des intervenants des cours d'instruction des FC sur la neutralisation des IED* afin de connaître les besoins des intervenants du cours d'opérateur de neutralisation des engins explosifs improvisés (IEDD) des FC en matière d'intégration et de validation de technologies d'apprentissage adaptatif. Vu le taux élevé d'échec au cours actuel d'opérateur IEDD, les aspects problématiques du cours ont été ciblés durant l'Analyse des intervenants. Les échanges avec les intervenants ont porté entre autres sur la faisabilité de la démonstration de la capacité de la technologie des tutoriels intelligents dans le cadre du cours d'opérateur IEDD. Le rapport présente les résultats des entrevues réalisées aux fins de l'Analyse des intervenants et recommande le plan de mise en oeuvre du système tutoriel intelligent (ITS) du cours d'opérateur IEDD, plus précisément son contenu et ses capacités, et explique plus en détail l'architecture théorique du tutoriel IEDD. On recommande aussi dans le rapport le plan d'évaluation du

système tutoriel intelligent du cours d'opérateur IEDD, des points de vue de la méthodologie et du calendrier approximatif des activités touchant l'évaluation du ITS.

Executive summary

Stakeholder Analysis for the CF Counter-IED Training Course

Simon Branbury, Kristina Osgoode, David Unrau, Chelsea Kramer, Jordan Miller; DRDC Toronto CR 2010-059; Defence R&D Canada – Toronto.

This document presents the results of a Stakeholder Analysis of Canadian Forces (CF) Counter Improvised Explosive Device (IED) training courses. The Stakeholder Analysis was used to inform the design, development and evaluation of an Intelligent Tutoring System (ITS) for the IED Disposal (IEDD) Operator Course. This work was conducted under Contract W7711-09-8153/001/TOR "Intelligent Tutoring for Distance Learning" for Defence Research Development Canada (DRDC) Toronto by CAE Professional Services (CAE PS).

One of the most challenging activities for a distance education facilitator is to be responsive to student needs and customize the learning experience to the student's individual learning style, help socialize the student to the institution, and keep the learner engaged in spite of the isolated environment. To achieve these goals, Defence Research and Development Canada (DRDC) – Toronto has initiated an Applied Research Project (ARP) to investigate mechanisms to improve efficiency and effectiveness for the Canadian Forces (CF) distance learning capability.

In order to support these goals, a *Requirement and Stakeholder Analysis for the CF Counter-IED Training Courses* was undertaken by CAE PS to investigate the requirements of stakeholders of the CF IEDD Operator Course for the development of adaptive learning technology integration and validation plans. Given the high failure rate in the existing IEDD Operator Course, problematic aspects of the course was one of the foci of the Stakeholder Analysis. The discussion with stakeholders focused, in part, on the feasibility of demonstrating the capability of intelligent tutoring technology within the IEDD Operator Course.

The report presents the results of the Stakeholder Analysis interviews conducted between the 22nd January 2010 and the 23rd February 2010, and describes the recommendations for implementing adaptive learning and intelligent tutoring technologies into a suitable CF distance-learning course. Following this, the report describes the implementation plan for the IEDD Operator Course ITS, in terms of its content and capabilities, and describes the notional architecture of the IEDD ITS in more detail, as well as the schedule for the design, implementation and evaluation of the ITS. Finally, the report describes the evaluation plan for the IEDD Operator Course ITS in terms of the methodology and approximate schedule for activities pertaining to the evaluation of the ITS.

The report also recommends a number of tasks to be conducted early during the next phase of the project in order to provide more detailed plans for the implementation of ITS technologies within the IEDD Operator Course:

- Questioning technique literature review;

- Development and validation of the IEDD ITS mission scenario;
- Conduct taxonomic analysis (including instructional design); and,
- IEDD ITS development (iteration 1).

Sommaire

Analyse des intervenants des cours d'instruction des FC sur la neutralisation des IED

Simon Branbury, Kristina Osgoode, David Unrau, Chelsea Kramer, Jordan Miller; DRDC Toronto CR 2010-059; Defence R&D Canada – Toronto

L'une des tâches les plus difficiles qui incombe à l'instructeur à distance est de répondre aux besoins de l'apprenant et de personnaliser l'acquisition de connaissances en fonction du style d'apprentissage du stagiaire, d'entretenir la relation entre le stagiaire et l'établissement de formation et de conserver la motivation de l'apprenant malgré son isolement. Pour y parvenir, Recherche et développement pour la défense Canada (RDDC) – Toronto a lancé un Projet de recherche appliquée (PRA) afin d'examiner des moyens d'améliorer la rentabilité et l'efficacité de la capacité d'apprentissage à distance des Forces canadiennes (FC).

Dans cette optique, on a entrepris une *Analyse des besoins et des intervenants des cours d'instruction des FC sur la neutralisation des IED* afin de connaître les besoins des intervenants du cours d'opérateur de neutralisation des engins explosifs improvisés (IEDD) des FC en matière d'intégration et de validation de technologies d'apprentissage adaptatif. Vu le taux élevé d'échec au cours actuel d'opérateur IEDD, les aspects problématiques du cours ont été ciblés durant l'Analyse des intervenants. Les échanges avec les intervenants ont porté entre autres sur la faisabilité de la démonstration de la capacité de la technologie des tutoriels intelligents dans le cadre du cours d'opérateur IEDD.

Le rapport présente les résultats des entrevues réalisées aux fins de l'Analyse des intervenants et énonce des recommandations pour la mise en œuvre de technologies d'apprentissage adaptatif et de tutoriels intelligents dans le cadre d'un cours pertinent d'apprentissage à distance des FC. Ensuite, le rapport décrit le plan de mise en oeuvre du système tutoriel intelligent (ITS) du cours d'opérateur IEDD, plus précisément son contenu et ses capacités, et explique plus en détail l'architecture théorique du tutoriel IEDD, ainsi que le calendrier de conception, de mise en oeuvre et d'évaluation du ITS. En conclusion, on trouve le plan d'évaluation du système tutoriel intelligent du cours d'opérateur IEDD, des points de vue de la méthodologie et du calendrier approximatif des activités touchant l'évaluation du ITS.

On recommande aussi dans le rapport des tâches à accomplir au début de la prochaine étape du projet afin d'en arriver à des plans plus détaillés pour la mise en œuvre de technologies de tutoriels intelligents dans le cadre du cours d'opérateur IEDD :

- examen de la documentation concernant les techniques d'interrogation;
- élaboration et validation du scénario de mission en vue du système tutoriel intelligent (ITS) du cours d'opérateur IEDD;

- analyse taxinomique (y compris la conception pédagogique);

développement du système tutoriel intelligent en matière d’IEDD (première itération).

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1 INTRODUCTION

This document presents the results of a Stakeholder Analysis of Canadian Forces (CF) Counter Improvised Explosive Device (IED) training courses. The Stakeholder Analysis was used to inform the design, development and evaluation of an Intelligent Tutoring System (ITS) for the IED Disposal (IEDD) Operator Course. This work was conducted under Contract W7711-09-8153/001/TOR “Intelligent Tutoring for Distance Learning” for Defence Research Development Canada (DRDC) Toronto by CAE Professional Services (CAE PS).

1.1 Project Overview

One of the most challenging activities for a distance education facilitator is to be responsive to student needs and customize the learning experience to the student’s individual learning style, help socialize the student to the institution, and keep the learner engaged in spite of the isolated environment. To achieve these goals, Defence Research and Development Canada (DRDC) – Toronto has initiated an Applied Research Project (ARP) to investigate mechanisms to improve efficiency and effectiveness for the Canadian Forces (CF) distance learning capability. Two mechanisms to facilitate the learning experience are adaptive learning and intelligent tutoring technologies.

Adaptive learning in the context of e-learning involves creating a learning experience that purposely adjusts to various conditions by adapting to individual students’ learning needs based on measures such as their individual behaviour, workload, or performance. Similarly, ITSs are self-regulating systems for the control, delivery, and assessment of learning contents. Complex algorithms are designed to rely on feedback from the learner’s performance, prior exposure to knowledge, and learning rate to deliver, evaluate, and react according to pedagogical principles, educational goals, and implementation tools.

To make the technologies effective in a distance learning environment, the learning platform and adaptation mechanisms to customize the learning experience need to be investigated. The CF can also benefit from mobile devices in theatre for continuation and re-fresher training. The execution of this work has been contracted to CAE PS who will survey and synthesise the body of knowledge on principles and best practices for adaptation mechanisms and mobile learning technologies in education and training. The results of this study will be used to develop a technology implementation and validation plan.

In order to support these goals, the following tasks were conducted during the first phase of the ITS project (January to March 2010; see Figure 1-1):

1. *Literature Review on Suitable Adaptation Mechanism and Mobile Learning Technologies for Adaptive Learning and Intelligent Tutoring Environments*. To review and identify suitable adaptation mechanism and mobile learning technologies for adaptive learning and intelligent tutoring methods that would improve CF distance learning capabilities.

2. *Requirement and Stakeholder Analysis for the CF Counter-IED Training Courses*. To investigate the requirements of stakeholders of the CF C-IED Disposal Operator Training course for the development of adaptive learning technology integration and validation plans.

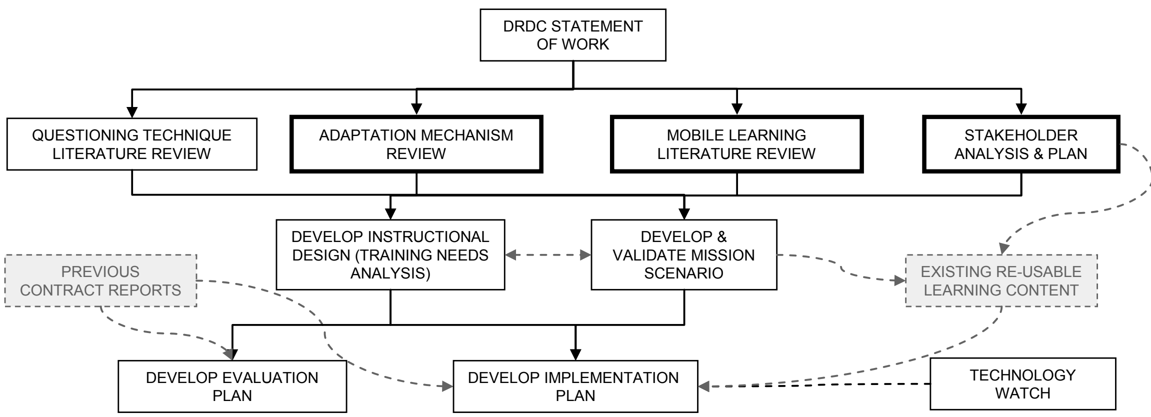


Figure 1-1: The relationship between tasks (and previous research) conducted within the ITS project. Current tasks are indicated in bold.

This report describes the results of the second task; the Requirement and Stakeholder Analysis for the CF Counter-IED Training Courses. Parallel research efforts have explored available technology and methodology for implementing real-time adaptive mechanisms into a CF training environment. This report is founded on several previously completed CAE PS reports concerning learning styles (Provonost, Roberts and Banbury, 2008), intelligent adaptive systems (Banbury, Gauthier and Scipione, 2007), and suitable adaptive learning and intelligent tutoring technologies (Banbury, Roberts, Hartlen and Unrau, 2009).

These initial reports provided a high-level overview of the requirements and availability of intelligent adaptive interfaces and techniques, such as determining the aspects of cognition that have been used to measure mental workload. Each subsequent report sought to narrow the overall scope in each respective area in order to focus on a specific type and context for which the intelligent interface would be implemented. Specifically, after learning of the overall types of research being conducted on adaptive learning, the second and third reports investigated specific technologies that could possibly adapt to the human learner, as well as which DND learning environment would be the ideal platform for proof of concept. These studies are described briefly in the following section.

1.2 Previous Research Conducted by CAE PS

Results of CAE PS's previous research produced a number of recommendations for the implementation of adaptive learning and intelligent technologies into the IEDD Operator Course. The identification of recommendations for implementing adaptive learning and intelligent tutoring technologies is also the basis of this report; however, efforts have been taken to tailor the recommendations to meet the specific needs of the IEDD Operator Course. To alleviate the need to refer to numerous documents, the following sections recap the main knowledge gained from the previous CAE contracts, as they are the underlying foundation supporting the stakeholder analysis.

1.2.1 Intelligent Adaptive Interfaces

The goal of this literature research was to provide support to establish guidelines for the effective design of Intelligent Adaptive Systems (IASs) through the review of frameworks, analysis tools and processes for IASs, and through the provision of general design recommendations and guidelines for the development of IASs, with particular emphasis on the operator machine interface (OMI). Combining design methodologies from both Human Computer Interaction (HCI) and Human Factors (HF) fields, conceptual and design frameworks were also developed to provide guidelines for the design and implementation of IASs. Finally, a number of criteria that can be used to select appropriate analytical techniques and design approaches were also developed.

After reviewing the approaches concerned with the design of an intelligent adaptive system, a generic conceptual architecture was developed. It has the following four components, which are common to all developed and developing IASs:

- *Situation Assessment and Support System*. This provides information about the objective state of the aircraft/vehicle/system within the context of a specific mission, and uses a knowledge-based system to provide assistance (e.g., automate tasks) and support to the operator.

- *Operator State Assessment*. This provides information about the objective and subjective state of the operator within the context of a specific mission relating to real-time analysis of the psychological, physiological and/or behavioural state of the operator (e.g., continuous monitoring of workload, inferences about current attentional focus, ongoing cognition, visual and verbal processing load), and intentions using extensive a priori operator knowledge (e.g., models of human cognition, control abilities. and communication).

- *Adaptation Engine*. This utilizes the higher-order outputs from Operator State Assessment and Situation Assessment systems, as well as other relevant aircraft/vehicle/system data sources, to maximize the match between

aircraft/vehicle/system state, operator state, and the tactical assessments provided by the Situation Assessment system.

- *Operator Machine Interface (OMI)*. The means by which the operator interacts with the aircraft/vehicle/system in order to satisfy mission tasks and goals. This is also the means by which, if applicable, the operator interacts with the intelligent adaptive system (e.g., a tasking interface manager).

Figure 1-2 illustrates how all four components operate within the context of a closed-loop system: a feedback loop re-samples operator state and situation assessment following the adaptation of the OMI and/or automation. The goal is to adjust the level of adaptation so that optimal operator states (e.g., performance, workload etc) are attained and maintained.

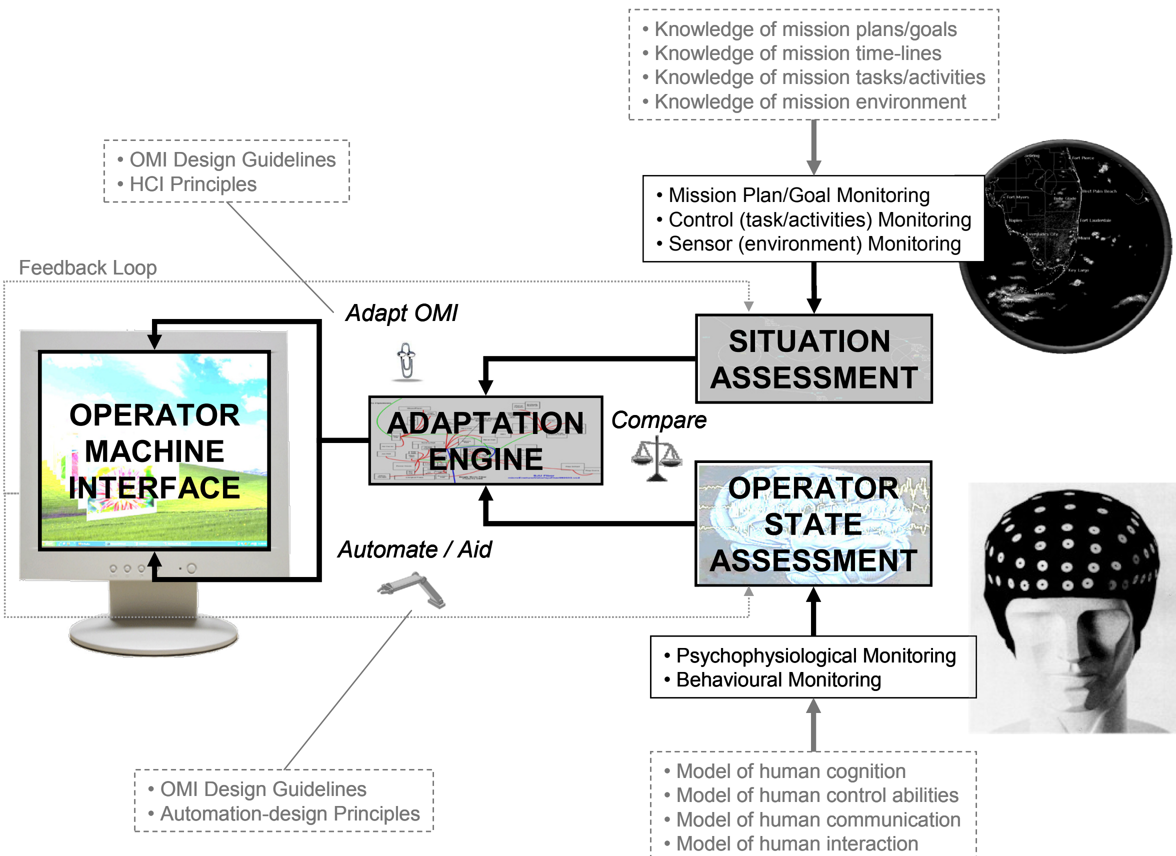


Figure 1-2: IAI Conceptual Architecture for Intelligent Adaptive Systems

The literature research pertaining to IASs demonstrated that when automation and interface adaptation that are implemented dynamically and intelligently (i.e., in response to changing task demands placed upon the operator), the chief benefits of automation

(e.g., workload regulation) can be realised without most of the drawbacks associated with conventional or static automation (e.g., loss of Situation Awareness). The review achieved of the following goals:

- Identified the advantages, disadvantages and applicability of development frameworks, analysis methodologies, design approaches, and operator-state monitoring approaches;

- Made some progress in unifying the hitherto independent HF and HCI approaches to the development of IASs by providing a generic conceptual framework and a generic conceptual architecture which map to both approaches by focusing on system functionality and capability; and,

- Integrated design methodologies from both HCI and HF fields and develop guidance for developers to assist in the successful design, development and implementation of IASs, with particular emphasis on the development of the OMI. A number of criteria for the selection of appropriate analytical and design methodologies were also recommended. The present report utilises the decision trees developed by Banbury et al., (2007) to select the most appropriate tools and methodologies for the IEDD Operator Course ITS.

1.2.2 Cognitive Learning Styles

Students approach learning tasks and interact with learning environments in different ways; they develop a specific set of learning behaviours, described as ‘learning styles’ that they are comfortable with (Entwistle, 1981). The objective of this review was to survey and synthesize the body of knowledge on student learning styles and develop recommendations on how to integrate knowledge of the learning styles of the learner into adaptive learning and intelligent tutoring technologies to facilitate a positive learning experience to improve CF distance learning capabilities.

The report reviews theories of student learning styles, relevant technologies to best exploit the different styles in education and training, principles, and methodologies of implementations in learning environments, particularly in distance/e-learning environments. The flexibility offered by such environments should enhance learning; allowing students to develop personal navigation patterns and interaction behaviour that reflects their own cognitive characteristics.

The review concluded that models based on learning styles have the potential to provide the theoretical background for designing educational systems, build their user model and functionality, and guide decisions about what the system should offer to students with different styles in the case of adaptive educational systems. The final section of the report provided recommendations based on the literature review, as well

as integrated and discussed some case studies that have had positive experiences after integrating knowledge of the student's learning styles into Intelligent Tutoring Systems (ITSs).

The literature research concluded the following:

- While the overall assessment of learning style models has been rather inconclusive it should not undermine their potential to support e-learning technologies. Indeed, any increment in user satisfaction or perceived usability of ITSs may justify the means undertaken.

- Another important aspect to consider is the ratio of benefits relative to costs incurred for the prototyping, development, implementation, maintenance, and collateral investments related to a system such as training and updates. The implementation of intelligent tutoring systems that adapt to the learning style of the student is far from simple, and the benefits of its realization may not outweigh its costs; particularly in light of the rather minimal benefits observed our review of the learning styles literature.

- Proposal of three design options – (i) an overarching system to be built bottom-up, (ii) staying with current technologies, or (iii) amending existing technologies to accommodate new interests – need to be carefully assessed based on a balance of resources and requirements.

1.2.3 Feasibility of Adaptive Learning and Intelligent Tutoring Technologies

The feasibility study of adaptive learning and intelligent tutoring technologies had two main objectives: The first was to review and identify suitable Adaptive Learning and Intelligent Tutoring technologies that could be integrated into the DND Learn environment to improve CF distance learning capabilities. The second objective was identify a suitable CF training course that can demonstrate the benefits of these technologies, together with identifying suitable integration components and designing an implementation and evaluation framework.

Objective 1: The results of the literature review demonstrated a range of maturing technologies that can be usefully applied to CF e-learning initiatives. The components that could be incorporated are:

- *Eye Tracking*. Eye tracking affords insight into the student's locus of attention. This information can be used by both the instructor and the system. The visual significance attributed by the student to features in a simulated scene can be compared to significances obtained from the training objectives or from tracking data recorded from subject matter experts (SMEs).

- *Electroencephalography (EEG).* Data can be correlated with training content events to develop workload measures. The workload component of the student model can then be updated using this information.

- *Heart Rate Variability (HRV)*. This measure can be used to infer overall levels of stress, and students' affective level of arousal in reaction to presented stimuli.

- *Galvanic skin response (GSR)*. Also known as electrodermal response (EDR), psychogalvanic reflex (PGR), or skin conductance response (SCR), this technology can be used as an indicator of the students level of excitement or relaxation.

- *Student Interaction Measures.* Information from the training delivery can be compared to knowledge of the training content to obtain measures of student proficiency, pace and behaviour. Where possible, this information should be handled in a fashion that does not preclude Sharable Content Object Reference Model (SCORM) compliance. However, the implementation limitations of SCORM around virtual simulation dictate that full SCORM compliance will not be possible.

Objective 2: The results of the review demonstrated that the IEDD Operator Course was the most suitable CF training course for the integration of adaptive learning, intelligent tutoring and cognition monitoring technologies. A number of factors were taken into account by the analysis, for example:

- *The extent to which the course is appropriate for the integration of advanced learning technologies*. For example, it would be beneficial to the study if the course delivery can be usefully implemented within a variety of environments to allow the greatest flexibility for adapting both course content and delivery method;

- *The extent to which the course includes the training of complex skills*. For example, it would be beneficial to the study if the course content included the instruction of complex cognitive skills (procedural knowledge) – as opposed to 'how to' (declarative) knowledge – to allow the greatest flexibility for adapting both course content and delivery method based on the student's learning style;

- *The extent to which the course has high student failure rate.* For example, it would be beneficial to the study if there is a relatively high student failure rate in the course as this would mitigate any ceiling effects that might be observed when evaluating the utility (i.e., 'added value') of adaptive learning technologies.

The IEDD Operator Course is designed to instruct soldiers in skills and procedures relating to the identification and disposal of IEDs in operational and domestic settings together with related administrative duties in support of IEDD operations.

1.3 Scope and Objectives

The objective of this task is to investigate the requirements of key stakeholders of the CF IEDD Operator Course for the implementation and evaluation of adaptive learning and intelligent tutoring technologies within that course. Given the high failure rate in the existing IEDD Operator Course, problematic aspects of the course was one of the foci of the Stakeholder Analysis. The discussion with stakeholders focused, in part, on the feasibility of demonstrating the capability of intelligent tutoring technology within the IEDD Operator Course.

1.4 This Document

The structure of this document is described below:

- *Section 2*. Presents the results of the Stakeholder Analysis interviews conducted between the 22nd January 2010 and the 23rd February 2010. This section also describes the recommendations for implementing adaptive learning and intelligent tutoring technologies into a suitable CF distance-learning course;

- *Section 3*. Describes the implementation plan for the IEDD Operator Course ITS, in terms of its content and capabilities. This section also describes the notional architecture of the IEDD ITS in more detail, as well as the schedule for the design, implementation and evaluation of the ITS;

- *Section 4*. Describes the evaluation plan for the IEDD Operator Course ITS in terms of the methodology and approximate schedule for activities pertaining to the evaluation of the ITS; and,

- *Section 5*. Summarises the results of the stakeholder analysis, and provides recommendations for the next steps for both the implementation plan and evaluation plan.

2 STAKEHOLDER ANALYSIS

This section presents the results of the Stakeholder Analysis interviews conducted between the 22nd January 2010 and the 23rd February 2010. Following a general introduction, this section describes the methodology utilised for the analysis, followed by the results. The final part of this section describes the recommendations for implementing adaptive learning and intelligent tutoring technologies into a suitable CF distance-learning course.

2.1 Introduction

The objective of the Stakeholder Analysis was to investigate the requirements of stakeholders of the CF C-IED Disposal Operator Training course for the development of adaptive learning technology integration and validation plans. The Stakeholder Analysis comprised two components:

1. *Investigation of Current Training Tools for C-IED Task Forces*. This component of the analysis sought to identify and scope: (i) stakeholders and their requirements; (ii) their existing instructional content, and (iii) their plans for future content and training directions and requirements. The following stakeholders were identified by the Scientific Authority:

    a. Counter-IED Task Force / Training, National Defence Headquarters (NDHQ) (Ottawa, ON);

    b. IEDD Operator Training and C-IED Defeat the Device Center of Excellence, CF School of Military Engineering (CFB Gagetown, NB)

    c. C-IED Attack the Network, Combat Training Centre (CFB Gagetown, NB); and,

    d. Counter-IED Technology Demonstration Project (TDP), DRDC Toronto (Toronto, ON).

2. *Investigation of E-Learning Environments and Learning and/or Content Management Systems*. This component of the analysis sought to identify the suitability of e-learning environments and learning material authoring software such as Learning and/or Content Management Systems, and assess the integration feasibility of different application software in multiple learning environments. The following stakeholders were identified by the Scientific Authority:

a. Institute for Information Technology, National Research Council of Canada (Fredericton, NB);

b. Directorate of Land Synthetic Environments (CFB Kingston, ON); and,

c. Directorate of Learning Innovation, Canadian Defence Academy (CFB Kingston, ON).

The details regarding the timing and points of contact for each of the Stakeholder Analysis meetings are presented in Appendix A. The following sections describe the work conducted under the auspices of the stakeholder analysis.

2.2 Stakeholder Meetings

Prior to the commencement of the stakeholder meetings, CAE PS identified a number of discussion points in the context of CF distance learning, and circulated them in advance of the meetings. The discussion points encompassed the two components of the stakeholder analysis identified in the previous section. Specifically:

1. *Training courses supported*. To gain an appreciation of what Counter-IED courses each stakeholder is supporting, the discussions were focused on those courses that require simulation-based training, and/or training of complex cognitive skills (e.g., Situation Awareness and decision making). Given the recommendations of the Banbury et al., (2009) report, particular emphasis was placed on the IEDD Operator Course;

2. *Training content developed*. For those courses identified above, the discussions were focused on what types of content has already been created, and in what format. The exploitation of existing content for the development of the ITS course was also discussed;

3. *Content development tools used*. The discussions were focused on the content development tools that have been used in the past, those used currently, and those that might be used in the future. In addition, any capability gaps between what content the stakeholder would like to develop and what the tools of the stakeholder could currently support was also discussed. This knowledge will the ITS project team determine which development tools should be adopted.

4. *Future training delivery plans*. The discussions were focused on the future role of serious game-based technologies, and mobile computing (e.g., iTouch, palm PCs, hand-held gaming devices) in future plans for delivery of training content; and,

5. *Past, present and future challenges*. Finally, the discussions focused on any insights into the kinds of challenges that have experienced by the stakeholder in the past, those experienced currently, and those that they expect to experience in the future. As well as informing the decision making about how the ITS course might be implemented, the ITS project team is keen to leverage any lessons-learnt during the ITS project, to help the stakeholder overcome their challenges.

This list of discussion points was not exhaustive; in fact, the discussions covered many related topics. The content of the discussions were recorded in Mindjet's MindManager™ application.

2.2.1 Results

The following section provides a top-level summary of the discussions had during each stakeholder meeting. Detailed notes pertaining to each of the stakeholder meetings are presented in the accompanying MindMap.

2.2.1.1 Counter-IED Task Force / Training (NDHQ, Ottawa)

The following issues were discussed with Maj Schurman and MWO Crosby during this stakeholder meeting:

- *IEDD Operator Course*. Participants discussed several aspects of the IEDD Operator Course, including general course information, and potential avenues in which adaptive learning and intelligent tutoring technologies might be implemented. Specifically:

    - <u>General course enrolment information</u>. Students are required to have at least four years of service before taking the course. The Advanced Munitions Disposal course is a pre-requisite for some occupations. Navy divers are the most successful trade, although the reasons as to why this is the case are not clear.

- *IEDD Operator mission scenario*. Participants discussed several aspects of typical IEDD mission scenarios. Specifically:

    - <u>IEDD team information</u>. The IEDD team comprises two operators; the Number 1 that conducts the disposal tasks, and the Number 2 that assists the Number 2. The team's Commanding Officer (CO) will give the initial briefing to the team, and will also answer any questions (e.g., relevant intelligence) that the IEDD team might have.

- IEDD Operator Course scenarios. The course uses a number of scenarios to train and evaluate students. At present, nine scenarios are run; two are based on domestic operations, and seven are based on Afghanistan operations.

- IEDD mission scenario. A typical IEDD mission scenario was discussed in detail. It was suggested that this type of scenario should be used for the ITS project. Further analysis is required to decompose the mission scenario into sufficient detail in order to identify the cognitive components (e.g., decision making requirements, Situation Awareness 'elements') and learning points (i.e., Training Needs Analysis). A typical mission comprises the following high-level functions:

  - Receive briefing – Communication with IEDD cell after blast or suspected IED. Receive briefing before departure. Additional briefings en route.

  - Arrive on scene and conduct threat assessment – Discuss situation with On Scene Commander (OSC) and question witnesses to assess threat and determine appropriate RSP (Render Safe Procedure).

  - Conduct disposal – Procedures followed according to which RSP was determined. This plan might be modified in light of new information acquired during the disposal process (e.g., finding evidence of other IED components).

  - Conduct After Action Review (AAR) – Receive feedback on the IEDD team's decision making and workload management.

- *Links with other CF projects / initiatives.* NDHQ is the strategic headquarters of counter-IED efforts. Participants discussed how the Counter-IED Task Force project is linked with other CF projects and initiatives. These links are as follows:

  - CFB Gagetown. New training cell and instructors at the Combat Training Centre (Maj Durant) and the School of Military Engineering (Capt Gilbert).

  - Directorate of Land Requirements (DLR). Interaction as part of the Counter-IED Task Force. NDHQ is acting as point of contact for these efforts.

  - Directorate of Land Synthetic Environments (DLSE). Minimal contact with Capt Taff at the DLSE, although this is likely to change soon in order to roll-out IED efforts to the rest of the Army. It is important that the technologies adopted are compatible with their plans.

2.2.1.2 IEDD Operator Training and C-IED Defeat the Device Center of Excellence (CF School of Military Engineering, CFB Gagetown)

The following issues were discussed with Capt Gilbert, WO Drolet and WO Lefort (IEDD Operator Training – Instructor) during this stakeholder meeting:

- *Operational conditions*. IEDD operators in Afghanistan are currently responding to 3 to 4 call-outs per day. As a result, there is an enormous amount of pressure on the IEDD operators, and they frequently experience burn-out.

- *IEDD Operator Course*. Participants discussed several aspects of the IEDD Operator Course, including general course information, and potential avenues in which adaptive learning and intelligent tutoring technologies might be implemented. This information is presented in Section 2.4.1 IEDD Operator Course Analysis.

- *IEDD Operator ITS mission scenario*. Participants discussed the potential of adding an additional practice scenario before the evaluations. This scenario would provide the ITS project team the opportunity to evaluate the impact of adaptive learning and intelligent tutoring technologies within the IEDD Operator Course, that would both, (i) afford the ITS project team with an opportunity to fully-exercise a range of adaptive learning and intelligent tutoring technologies, and (ii) provide the greatest possible benefit to students on the IEDD Operator Course. This information is presented in Section 2.4.1 IEDD Operator Course Analysis.

- *Evaluation of ITS technologies with the IEDD course.* Participants discussed the constraints pertaining to conducting the evaluation of the ITS scenario with students from the course. No control condition in which some students have a 'lesser learning experience' will be acceptable. Manipulation of mechanisms of adaptation should not change the content just how it is delivered, with no impact on both the quality and the duration of the training.

- *Links with other CF projects / initiatives.* Participants discussed how the Defeat the Device Centre of Excellence and the IEDD Operator Course are linked with other CF projects and initiatives. These links are as follows:

    - Defeat the Device Centre of Excellence (CFB Gagetown). IEDD operators will often try to render-safe the device through deactivation rather than destruction. In doing so, forensic analysis can be undertaken to inform and refine disposal procedures, as well as identify the network through which the device was funded, constructed, transported and installed. The Defeat the Device Centre of Excellence has been using Virtual Battle Space 2 (VBS2) to create training videos for IED awareness; albeit not yet for the

IEDD Operator Course. These videos were developed by the Combat Training Centre, CFB Gagetown.

- Combat Training Centre (CFB Gagetown). Collaboration with Capt Fox, who is using VBS2 to create training videos for a range of mounted and dis-mounted tactics; including IED awareness.

- C-IED TDP (DRDC Toronto). Collaboration with Dr Jerzy Jarmasz and Sgt. Wojtarowicz regarding development of VBS2 environments relating to C-IED.

2.2.1.3 C-IED Attack the Network (Combat Training Centre, CFB Gagetown)

The following issues were discussed with Maj Gimby and Capt Fox during this stakeholder meeting:

- *Simulation-based tools used.* Participants discussed what simulation-based tools were currently being used by the Combat Training Centre.
  - VBS2. Current development using VBS2 is restricted by classification; content is now being developed by intern students in partitions to avoid classification issues. VBS2 is being used to create training videos. For example, the re-construction of scenarios that happened in the last 30 days to enable knowledge sharing. This is a cost-effective means of producing training videos and content.
  - Other tools. The Combat Training Centre is exploring ‘parallel’ paths to develop content in other 3D modeling tools due to issues relating to VBS Gold version licensing.
  - Flash. Content is being developed using Flash within DND Learn.
- *Simulation-based content generated.* Participants discussed what simulation-based content has been generated that might be re-purposed for the ITS project.
  - VBS2 models in development. Seven training videos have been produced and have been given to CAE PS. The videos are set in Afghanistan-like situations; with models pertaining to CF vehicles, personnel, and terrain features.
- *Future modeling efforts.* The team would like to integrate real terrain and building imagery into the simulation software.

- *Training courses supported*. The participants discussed the Tactical Exploitation course which is run under the auspices of the Defeat the Network initiative. This is a three week course, which includes eight days of scenarios and evaluation. The course focuses on forensics, evidence and tactical questioning (e.g., pattern matching, and social networking). Although this course has a 100 percent pass rate at present, the participants noted that a training scenario in a simulated environment would be useful to keeps these skills refreshed.

- *Links with other CF projects / initiatives.* Participants discussed how the Defeat the Device Centre of Excellence and the IEDD Operator Course are linked with other CF projects and initiatives. These links are as follows:

    - C-IED TDP (DRDC Toronto). Collaboration with Dr Jerzy Jarmasz and Sgt. Wojtarowicz regarding development of VBS2 environments relating to C-IED. For example, the Environmental Familiarisation and Indicator Trainer (EFIT).

    - School of Military Intelligence (CFB Kingston). Point of contact Maj Terfry regarding the Tactical Questioning course.

    - CF School of Communications and Electronics. Point of contact Capt Shea regarding Counter IED initiatives (Defeat the Device).

    - Army Learning Support Centre (ALSC). Point of contact Maj Batty (TDOs Maj Standish and Lt. Navy Paula Jardine). ALSC are leaders in the development of VBS content and learning strategies. VBS products are also developed by student interns.

    - Defeat the Device Centre of Excellence (CFB Gagetown). From an Electronic Warfare (EW) perspective.

2.2.1.4 Institute of Information Technology (NRC, Fredericton)

The following issues were discussed with Dr Rod Savoie, Dr Marc-Allain Mallet and Dr Bruce Spencer during this stakeholder meeting:

- *Related Projects.* Participants discussed several projects at the NRC that are relevant to adaptive learning and intelligent tutoring technologies. These projects are as follows:

    - Personal Learning Environment (P-Learn) – learner-oriented access to Learning Content Management Systems (LCMS), such as Desire2Learn;

    - Cognitive modeling;

- Natural language processing;
- Data and text mining summary tool;
- WEBDAV – an automated web-authoring tool for content development, integrated into DND Learn; and,
- Doctor-patient interview adaptive learning system.

2.2.1.5 Directorate of Land Synthetic Environments (DLSE) (CFB Kingston)

The following issues were discussed with Capt Taff and Dr Roman during this stakeholder meeting:

- *DLSE Background.* The DLSE is responsible for the collective training of the army for section level and above. Capt Taff is the project manager for the simulators at DLSE, which includes responsibility for the purchasing of VBS2 and the software development team (approximately 25 persons in Kingston and Ottawa). The development team creates interfaces and smaller tools, and provides support to DRDC projects and development; for example, VBS2 support and the provision of standardised development approaches. Capt Taff provides a good point of contact for all simulation development initiatives (including VBS2) within the Army.

- *Simulation-based tools used or examined.* DLSE has looked into Olive's Forterra and Linden Lab's Second Life virtual environments. However, both approaches were not followed given the requirement to acquire open-source and simulation-independent architectures in order to be future-proof as much as possible.

  - VBS2. VBS2 has been used for counter-IED training; for example convoys and recognising IED indicators. Nearly all this training content is unclassified. In addition:

    - DRDC (and CAE PS through the ITS contract) can be given free licenses. Negotiation with Bohemia Interactive will be completed by 31 March 2010, and access to the licenses should be possible by May 2010. These licenses might include Bohemia Fusion which is a third-party tool creation package for VBS2.

    - DLSE can provide VBS2 modeling and coding support to the ITS project through sub-contracts.

    - The ITS project can have access to all VBS2 models developed by the CF (at least in principle) for re-purposing for the IEDD scenario.

- Ngrain. Ngrain models have been used for mine clearance. 300 types of mines have been developed in Ngrain for use with a mobile device as an in-field rehearsal tool. These models are unclassified and can be re-purposed for the ITS project as required.

- Delta 3D. Delta 3D is an alternative to VBS2 that is an open-source game engine developed by the US Naval Postgraduate School. The tool is useful for research; however the game engine is older than VBS2 and requires specific expertise to code the tool.

- CAMIX. The CAMIX (Civilian Modeling Experimentation) tool is also a promising approach that integrates with VBS2 to model realistic civilian reactions to events (e.g., bomb blast). CAMIX is a simulation-independent tool developed by DRDC. Lessons learnt from the ITS project might be useful for the development of CAMIX.

- *Links with other CF projects / initiatives.* Participants discussed how DLSE is linked with other CF projects and initiatives. These links are as follows:

  - C-IED TDP (DRDC Toronto). Collaboration with Dr Jerzy Jarmasz and Sgt. Wojtarowicz regarding development of VBS2 environments relating to C-IED. For example, the Environmental Familiarisation and Indicator Trainer (EFIT).

2.2.1.6 Directorate of Learning Innovation, Canadian Defence Academy (CFB Kingston)

The following issues were discussed with LCdr Tremblay (Senior Staff Officer, Learning Concept Development) during this stakeholder meeting:

- *CDA Initiatives*. The following CDA initiatives relevant to the ITS project were discussed:

  - Simulation tools. Second Life and Open Second Life is not currently in favour due to problems with the contracting vehicle. Current plans are to move over to OpenSim. OpenSim is currently being integrated into DND Learn's Learning Management System (LMS) and with content developed for Second Life. Public Works have created an Expression of Interest for a government-wide virtual world. VBS2 is currently in the process of being purchased and a number of air traffic control scenarios have been developed.

  - Mobile Learning. CDA conducted a literature review two years ago to examine the utility of mobile devices to enhance training and performance.

- Physiological feedback. CDA is conducting a technology watch on biofeedback for students.

- *Links with other CF projects / initiatives.* Participants discussed how the CDA is linked with other CF projects and initiatives. These links are as follows:

  - Institute of Information Technology (NRC). Interaction with Personal Learning Environment from a social networking point of view.

  - Alelo. CDA is investigating how Alelo dialogue coaching tools can be integrated into VBS2 for air traffic control applications.

- *List of Actions*. The following actions were recorded during the stakeholder meeting:

  - Contact Directorate of Military Personnel Operational Research and Analysis (DMPORA) for ethical approval to collect physiological data from CF personnel.

2.2.1.7 Counter-IED TDP, Collaborative Performance and Learning Section (DRDC Toronto)

The following issues were discussed with Dr Jarmasz (Defence Scientist, Learning and Training Group) and Sgt Wojtarowicz (Project Coordinator, IED Awareness Training Project) during this stakeholder meeting:

- *IED Awareness Technology Demonstration Project*. The following aspects of the DRDC-Toronto IED TDP initiatives relevant to the ITS project were discussed:

  - Overview of TDP. The TDP seeks to improve soldiers' skills at visually assessing IED threats; for example, identification of relevant cues and assessing threat levels. The focus is on mounted operations.

  - Environmental Familiarisation and Indicator Trainer (EFIT). EFIT uses video footage recorded from CF vehicles in operations to familiarise CF personnel with the routes and likely IED indicators along them before arriving in theatre. A voice commentary and visual overlays on the video help to orient the student to potential IED indicators along the routes that they will drive along when deployed. The project has also examined eye tracking data (e.g., scan patterns compared between experienced and non-experienced personnel) and psychophysiological measures (e.g., heart rate variability and galvanic skin response).

- VBS2 Training Videos. DRDC is involved with the development of training videos for the Combat Training Centre (CFB Gagetown) using content and scenarios developed in VBS2. The videos provide a demonstration of the skills associated with convoys.

- Counter IED Immersive Training Environment (CIITE). DRDC has contracted Chi Systems Inc. to develop intelligent agents (i.e., non-player characters) within synthetic environments. This project is currently on hold; however the CIITE and ITS projects should look for opportunities to collaborate in the future.

- *Experiences using VBS2.* DRDC have used VBS2 to create scenarios and content pertaining to the training of counter-IED scenarios. Participants discussed the lessons learnt from this experience.

  - The VBS game engine is not able to provide a level of detail for some IED indicators; such as physical features of the terrain (e.g., terrain changes, ditches, hills, elevated roads), and avatars (restricted to walk, crawl, shoot etc). Having said that, Bohemia's Fusion development tool-set should mitigate most of these issues. In addition, the CF has requested a number of changes to VBS in terms of more Canadian content (e.g., vehicles, small arms etc), more realistic vegetation and better road patches.

- *Links with other CF projects / initiatives.* Participants discussed how the Defeat the Device Centre of Excellence and the IEDD Operator Course are linked with other CF projects and initiatives. These links are as follows:

  - Combat Training Centre (CFB Gagetown). The CTC uses, and supports, the EFIT project.

  - United States Research and Development Engineering Command (US RDECOM). RDECOM have developed techniques measure affective state to adapt learning environments. For example, using mouse movements and patterns. Participants discussed the benefits of collaborating with personnel at RDECOM during the ITS project.

2.2.2 Summary

In summary, the stakeholder meetings were a success insofar as they provided a rich source of information and advice for the implementation of ITS technologies, and an opportunity to establish relationships with the stakeholders of the ITS project. The key outcomes were as follows:

1. The selection of the IEDD Operator Course for implementation of adaptive learning and intelligent tutoring projects is appropriate.

2. The IEDD Operator Course personnel are keen to support the ITS project in terms of access to course materials, instructors and students.

3. There was a clear consensus that Second Life is *not* an appropriate environment[1] (as we had first thought) in terms of the selection of the appropriate simulation and modeling tools to implement the IEDD Operator Course ITS. Bohemia Interactive's VBS2 should be the tool of choice.

4. DLSE has offered to provide VBS2 support to DRDC (and CAE PS through the ITS contract) in terms of software licences, a smaller terrain map, existing content, and modeling and coding support (through a sub-contract).

5. DRDC Toronto (C-IED TDP) is a key collaborator for the ITS project; both in terms of sharing VBS2 content pertaining to C-IED, and identifying future technology transfer opportunities (e.g., with the CIITE project).

The remainder of this section describes an analysis of the stakeholders and analyses of the IEED Operator course in order to inform the implementation and evaluation plans.

2.3 Stakeholder Analysis

This section summarizes the results of the stakeholder analysis, with particular emphasis on presenting results of the analysis of the IEDD Operator Course.

2.3.1 Methodology

The stakeholder analysis was conducted by collecting data during individual meetings with stakeholders. Stakeholders were identified through DRDC and other CF contacts in the statement of work. As work progressed additional stakeholders were identified and added to meeting agendas as possible. Stakeholder data were collected and summarized using a generic format built from CAE PS change management and communication planning best practices. A prioritization scheme has been identified using a common change management / stakeholder analysis power and involvement

[1] In addition to problems associated with licensing and contractual arrangements with Linden Labs, Second Life is not targeted at training or at re-use of standards based source data. There are no mechanisms for customization of the Second Life capability. There is a permissions structure to control 'visitor' access to land under the user's ownership, but the Second Life space is essentially public. Investigation has revealed that Linden Labs recommends 40 users as the peak concurrent user density for a region of land (Unrau et al., 1999). While Second Life supports a large number of users, it does not support a high density of users. Finally, given that Second Life is a virtual world (as opposed to a virtual environments), students of the IEDD Operator Course would need to schedule time within Second Life for them to be able to use the ITS training scenario.

frame presented using a structure built on MindTools™, power interest analysis for stakeholder prioritization (www.mindtools.com/rs/StakeholderAnalysis).

Stakeholders were identified using the following criteria:

1. Someone who is impacted by the project; and

2. Someone who can have an impact (positive or negative), on the project.

Stakeholders can be individuals, either identified by their job title or by the actual name, or they can be groups of individuals such as department or teams. They can also be organisations, approval bodies, and so on. This analysis identified eight stakeholder groups – all organizations. The nature of the data collected for each organization is described below (details and data are included in Appendix A):

- *Stakeholder organisation*. Understanding the stakeholder organization is important. The analysis provides the name and location of eight stakeholder organizations. This information should be reviewed yearly to ensure the ITS project maintains knowledge of changing titles, mandates and activities inside and outside of DND.

- *Stakeholder name and location*. The name and location of the individual identified as the ITS project's primary point of contact is included in the analysis. Where possible a second point of contact is also identified.

- *Stakeholder role*. The function, job and domain of responsibility of the individual stakeholder are included in the stakeholder analysis. This information helps identify the individual's interest, level of influence and provides a high level view of where the individual fits inside their organization.

- *Stake / interest in the ITS Project*. Based upon meeting outcomes, as well as the ITS team and DRDC client's knowledge and experience of the stakeholders groups and individuals, the analysis identifies why this person would be interested in this project. These data were assessed through meeting outcomes and notes taken during meeting discussions. It identifies what stake the individual has in the project by asking if it affects their job, their role, their perceived position within an organisational structure. This information assists in determining how the amount and type of communication the stakeholder could receive to maintain their interest and support.

- *ITS related programs and program links*. Data collected in the meetings identified stakeholder activities or projects that had related themes, capabilities or content. This included experience with technologies in evaluation to support elements of the intelligent tutoring and adaptive learning goals of the project. This information highlights related projects and programs that might lead to identification of

missing in stakeholders. It increases the project's knowledge of related projects and capabilities that may be useful align with and ensure activities are not duplicated but coordinated and aligned for a larger impact. This data also helps identify projects or individuals who act as central 'nodes' for information and knowledge in the research domain and related training or distance learning domains.

- *ITS related capabilities*. Meeting discussions informally identified the core activities and capabilities of the stakeholder groups. These capabilities were noted as either: capacity and knowledge of the people in the organization; processes that might be useful to leverage for the next phases of the project or, availability of knowledge of technologies. Capturing this data early in the ITS project enables the ITS project team and its partners to leverage the right stakeholders at the time, to solicit cooperation and buy-in for the project and identify overall efficiencies that could be achieved by involving stakeholder in various phases of the project.

- *Role in phase of project involvement*. The implementation plan identifies three phases of the ITS project: Analysis and Design, Implementation and Evaluation. Details of the timing and scope of activities in each of these phases are included in this report. The analysis reviews stakeholder interest, power, capabilities as discussed above to identify how best to involve the stakeholder in future phases of the project. Specific types of involvement will depend on the phase and the stakeholder. These are identified in the stakeholder needs section below.

- *Stakeholder needs*. In light of the information collected and analysis performed above, this section recommends what the stakeholder needs from the ITS team and what the ITS team could benefit from the stakeholder. Needs are characterized into four types:

    - Communication needs;
    - Information provision;
    - Advise and support; and
    - Inclusion in project team improvement activities.

- *Perceived attitude and associated risks*. Based upon the CAE PS team's experience dealing with this individual in the stakeholder meetings, the analysis provides an initial assessment of the stakeholder's attitude towards the ITS project.

- *Project impact on stakeholder*. The project impact on the stakeholder provides an indication of the priority, involvement and influence the stakeholder may have on

the project. A three level scale of high, medium, low was used to assess the ITS project's impact on the stakeholder:

- High: The stakeholder is significantly impacted by the outcome of this project.
- Medium: There will be some impact on the stakeholder from the outcome of this project.
- Low: There will be little or no impact to stakeholder from the outcome of this project.

- *Connection of other stakeholders*. Due to overlapping capabilities and relationships between organizations, this section of the analysis identifies a stakeholder's connection to other stakeholders included in this analysis. These data provide a high level view of direct and indirect relationships between stakeholders as well as linkages to corporate wide agencies and organizations such as Canadian Defence Academy (CDA), Defence Research Development Canada (DRDC) and the National Research Council (NRC).

2.3.2 Results

Meetings took place at the place of work of the eight stakeholder groups and their points of contact. In some cases, multiple points of contact were available to participate and contribute to the stakeholder meetings. The meetings were conducted using an informal approach designed to collect a wide range of information. The approach and outcome of these meetings are summarized in Section 2.2 of this report. The outcomes of the meeting that provided information into the stakeholder analysis were organized into eleven types of information as described in the methodology section above. The results of this data provide an overall picture of the stakeholders power, influence, interest and potential involvement in future phases of the ITS project. The stakeholders identified can be categorized as follows:

- 1 x Army Simulation and Technology Stakeholder;
- 3 x Subject Matter Experts in Army Training and Counter-IED;
- 2 x DRDC Stakeholders;
- 1 x DND Future Training Organization; and,
- 1 x Other Government Department

2.3.3 Recommendations

The implementation plan and conduct of the project must be cognisant of the roles of stakeholders during the different project phases. Areas for consideration in the detailed implementation plan are organized by project phase:

- *Analysis and design phase*. Identify areas where capabilities of stakeholders might afford the ITS project an advantage. During the analysis and design phase, the role of subject matter experts is particularly important and demands a higher level of involvement than during other phases. Communication and buy-in for stakeholders who may provide subject matter knowledge will be key during this phase.

- *Implementation phase*. Identify areas where capabilities of stakeholders may provide the ITS with an advantage. For instance, are there people in stakeholder organizations with the skills or knowledge to do reviews or contribute media content or technologies to the project?

- *Evaluation phase.* Identify appropriate stakeholders to participate in the evaluation of the project outcome, and stakeholders who can create a larger degree of support and information dissemination about the results of the ITS project.

Finally, it is recommended that the project team maintains a ‘technology watch’ throughout the duration of the project. The technology watch will include activities pertaining to:

- Monitoring of virtual world and gaming technologies;

- Monitoring role changes in the stakeholder community;

- Monitoring for new stakeholders;

- Maintaining stakeholder involvement at the right time;

- Communicating project outcomes with stakeholders and receiving any new findings or knowledge of the stakeholders themselves;

- Providing feedback loops as a way to keep stakeholders involved in the project; and,

- Ensuring that project deliverables are visible to the appropriate stakeholder (to be determined on a case-by-case basis).

2.4 IEDD Operator Course ITS Gap Analysis

The following section describes the IEDD Operator Course in terms of a general course overview, participants and the delivery methods employed. The objective of this section is to identify components of the IEDD Operator Course that would benefit most from the implementation of adaptive learning and intelligent tutoring technologies. This work builds upon the analysis conducted by Banbury et al. (2008).

2.4.1 IEDD Operator Course Analysis

This course enables CF personnel to identify, disrupt, and dispose of IEDs. Personnel will also be able to identify, recognize and formulate an accurate threat assessment of the suspected IED, and provide advice on immediate protective measures against hazards associated with chemical, biological, and radiological (CBR) improvised devices. This course excludes yield-producing nuclear weapons and devices.

2.4.1.1 IEDD Operator Course Overview

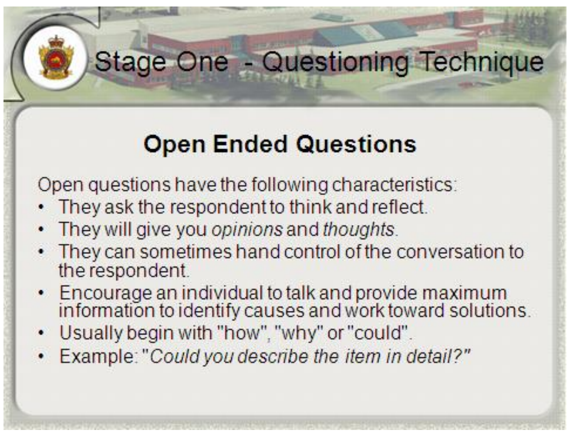
An IEDD team comprises of a Number 1, who fulfills the role of team leader, and a Number 2, who fulfills the role of an assistant to the Number 1 and operates the IEDD equipment (e.g., video, robot). Typically, the IEDD teams are called out to an incident involving a suspected (or exploded) IED or explosive device that has been discovered and are responsible for the safe disposal of the device. On arrival, the IEDD team sets up an ad hoc command post from a safe position where the robot can be controlled. In order to successfully dispose of the explosive device, it is critical that the IEDD team accurately identifies the type of device so that the correct Render Safe Procedures (RSPs) can be used. The threat assessment process involves both the close inspection of the device itself and the gathering of information from third parties (e.g., civilians, local police, CF personnel etc) through questioning to determine the level of threat posed to personnel by the device. Any information gleaned from these activities (e.g., intelligence about the type of devices used) is reported to Headquarters.

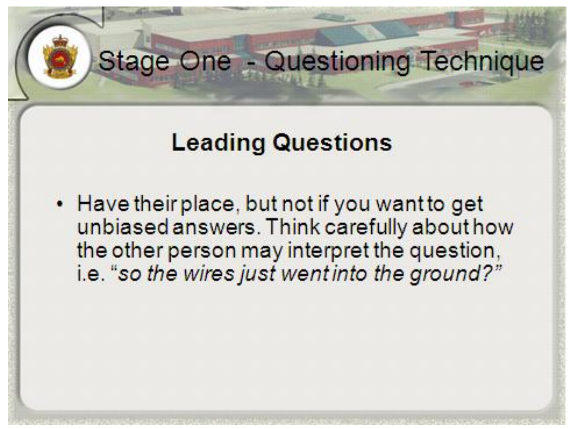
The IEED Operator Course is based on the Qualification Standard (QS) Improvised Explosive Device Disposal (IEDD) Operator (reference: A-P3-002-IED/PH-H01). The IEED Operator Course is aimed at qualifying students for the role of Number 1. All students on this course would have already qualified for the Number 2 role. In addition, the course enrolment also includes existing Number 1 qualified personnel who require re-qualification (the qualification is valid for three years).

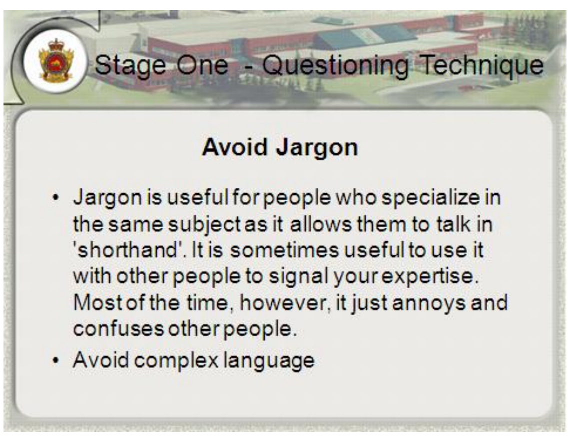
The following information was acquired over the course of the Stakeholder Analysis interviews and from previous discussions with Maj Schurman (NDHQ) conducted under the previous contract (Banbury et al., 2009).

- *General course information*. General course information was discussed as part of the stakeholder analysis meetings:
    - Course Participants. Students come from a broad range of backgrounds (e.g., AVN techs, Navy clearance divers, Ammo techs and combat engineers), with a broad mix of skills, rank and age. However, most students have a typical 'Type A' personality.
    - Course Schedule. There are three courses run per year (i.e., spring, summer and fall) with approximately 20 students per course.
    - Course Success. At present, there is a 40 percent failure rate due to deficiencies in skills associated with threat assessment. What those deficiencies actually are is not understood; however, the course instructors speculate this it is due to poor Questioning Technique skills.
- *Course phases*. The IEDD Operator Course is divided into three phases:
    - General knowledge. Instruction pertaining to three classes of IEDs (i.e., command-operated, timer-operated and victim-operated devices), and what components are used to construct / improvise these devices.
    - Skills. Instruction pertaining to threat assessment (which includes Questioning Technique), developing a plan based on the threat assessment, and the execution of that plan (i.e., following the appropriate RSPs). The Questioning Technique is by far the most difficult component of the course, and is currently taught using a combination of PowerPoint slides (see Figure 2-1) and classroom role-playing exercises. It was suggested by the IEDD Operator Course stakeholders that the ITS project concentrate on this aspect of the course, as it should have a significant impact on the failure rate. In addition, the disposal plan might have to be adapted in light of new information discovered during the execution of the RSPs. However, many operators are not flexible and reach premature (incorrect) conclusions from partial data, and do not change the plan in response to new data (i.e., confirmation bias). As such, it was also suggested that the ITS project concentrate on this aspect of the course as well, as it should have a significant impact on the failure rate also.
    - Scenario-based testing. Students receive nine scenarios in total. Six are practice scenarios (i.e., two command-operated scenarios, two timer-operated scenarios, and two victim-operated scenarios), and three are evaluation scenarios (i.e., one for each of the three classes of device). For the evaluation scenarios, students are divided into five teams of two students, and all teams receive the same scenario. Instructors play the role of witnesses to be questioning during the threat assessment phase,

and provide pre-determined responses to questions from students relating to the main teaching points (MTPs). The success of each student is determined by the student getting 90 percent of the available information from their questioning. Ideally, students should start to plan and execute the RSPs with 40 to 50 percent of the information and then re-plan (or not) when conducting the disposal and more information comes to light. Nevertheless, there are 20 to 25 questions that always need to be asked. These questions are broadly described as the “5 Ws” – what, when, where, why and who. However, there is not a checklist of questions; nor should there be. Rather, students are taught questioning technique, rather than what questions should be asked.







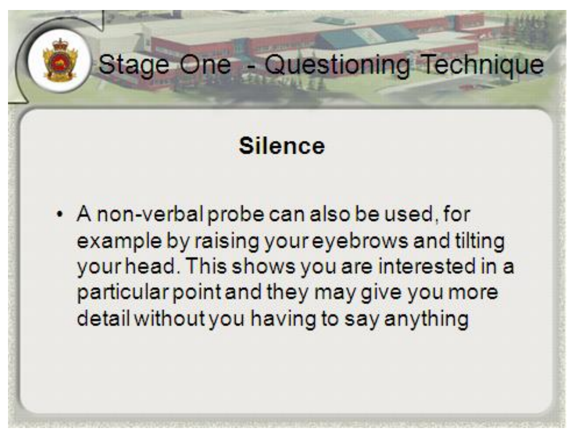


Figure 2-1: Example of Questioning Technique Course Content

2.4.1.2 Recommendations

This section provides a list of recommendations for tasks to be conducted early during the next phase of the project in order to support the implementation of ITS technologies within the IEDD Operator Course. Specifically:

1. *Conduct literature review on Questioning Technique*. In order to create new instructional material as part of the ITS scenario, a literature review of questioning techniques needs to be undertaken. The review should explore questioning and interviewing techniques used in qualitative psychology, doctor-patient interviews, police investigations (e.g., National Investigation Services). The review should also include cognitive biases that are thought to affect threat assessment and decision making (e.g., confirmation bias, cognitive tunnelling), and strategies by which questioners can adopt in order to mitigate them (e.g., problem solving and decision making techniques taught as part of aviation Crew Resource Management). The intention is for these biases, and means to mitigate them, will be explored within the auspices of the ITS scenario. The review should also include any lessons learnt from the meeting with Maj Terfry at the School of Military Intelligence (CFB Kingston) concerning the Tactical Questioning course, and Dr Bruce Spencer at the Institute for Information Technology (NRC, Fredericton) regarding the adaptive learning system for doctor-patient interviews. Finally, the review should also seek to identify the causes of failure of IEDD Operator Course students. Correlates to be examined should include existing psychometric data collected during enrolment into the CF. This work should be completed in collaboration with the relevant personnel at NDHQ who would provide the necessary data.

2. *Organise scenario development and instructional design workshop*. This workshop will support the development of a suitable mission scenario for the implementation of ITS-related technologies into the IEDD Operator Course. This should be held in May 2010 at the School of Military Engineering, CFB Gagetown. This workshop will also develop ITS training and evaluation scenarios based on the mission scenario. Specifically, Main Teaching Points (MTPs) will be developed for the following Performance Objectives (POs) from the Qualification Standard (QS) Improvised Explosive Device (IEDD) Operator (reference: A-P3-002-IED/PH-H01): PO 5.10 Good Questioning Technique, and PO 5.11 Task Appreciation / Threat Assessment. Finally, evaluation criteria for these POs will also be developed.

Section 3.4.4 describes how these tasks fit into the implementation schedule for the next phase of the project.

3 IMPLEMENTATION PLAN

This section of the report describes the implementation plan for the IEDD Operator Course ITS. The first part describes the implementation of the ITS in terms of its content and capabilities, and then describes the architecture of the ITS in more detail. The final part of this section describes the schedule for the design, implementation and evaluation of the ITS.

3.1 Background

Before describing the content and capabilities of the IEDD Operator Course ITS, this section reviews the results of parallel activities undertaken to review and identify adaptation mechanisms for adaptive learning and intelligent tutoring technologies (see Kramer, Tryan and Banbury; 2010).

Kramer and colleagues' report reviewed current techniques and technologies relating to eye-tracking, psychophysiological indices of workload and stress, learning styles and performance tracking that have been successfully used, or could theoretically be used, to augment the IEDD ITS. The purpose of the review was to provide straightforward, applicable recommendations that would lead to the purchase of technology that can be implemented into the IEDD ITS. The findings from this review are summarised in the following sections.

3.1.1 Eye Tracking-based Adaptation

Eye-tracking as a means of attention, workload, and expertise proved to be the most mature and commercially accessible technologies used in research. The recommended style of eye-tracker is a desktop, or screen-integrated eye-tracker, as they are the most non-invasive and should take the least amount of time to setup and calibrate as compared to a head mounted eye-trackers. Goggle style eye-trackers are appealing for their mobility, but are unnecessary and costly for use in front of a PC. The main limiting factor is price, as the higher quality and more frequently used models in peer-reviewed research tend to cost over $40,000. The suggested quality/price compromise is to purchase one mid-range ($10,000 or less) eye-tracker (such as the EasyGaze system) to use to collect baseline data and to calibrate the other systems. If numerous eye-trackers are needed to be left at the IEDD course, it is recommended to use open-source, or web-cam based alternatives which could be calibrated against the higher quality version purchased.

3.1.2 Psychophysiological-based Adaptation

The psychophysiological measure recommended for use is Heart Rate Variability (HRV) in either a simple ear-clip, dry-electrode wrist straps, or wireless Bluetooth model. HRV uses non-invasive techniques for assessment, and could be used in combination with eye-tracking to help triangulate a more accurate meaning of general arousal to specific stimuli. The technology recommended for purchase HRV Live! from the company Biocom.

EEG, while a valuable and proven source of mental workload and other cognitive functions, is not recommended as a form of adaptive measure within the current ITS. First and foremost, the equipment and setup time required to acquire accurate EEG recordings makes it unlikely to be usable by IEDD operators without assistant or researcher supervision. The ITS needs to be a standalone learning tool that is readily accessible by students. If the ITS requires an hour for placing gels and electrodes on one’s scalp, it is doubtful that it will be used for more than purely research purposes when the experimenter is present.

3.1.3 Learning Style-based Adaptation

The Index of Learning Styles (Felder and Solomon, 2006) is recommended to be given to students prior to using the IEDD ITS. The ILS has proven validity and reliability, is freely available and automatically scored online, and takes only a few minutes to complete. It is further recommended to administer the index during baseline testing in order to get a sense of any dominant learning styles. These results would help to provide guidance for content building within the actual ITS; such as a preference for visual over auditory learning styles.

3.1.4 Attention Tracking-based Adaptation

Performance tracking measures produced the least amount of tangible technologies that could be implemented into the IEDD ITS. While motion tracking offered some interesting research streams for performance tracking based on postures, at this point, the related technologies are only academic prototypes. The most plausible form of performance tracking appears to be speech recognition. This has matured in the field of language training as in Rosetta stone, but is still in need of improvement for Alelo. The problem is that the project is not in need of a language training just yet, so this technology is likely too complex and not reliable enough to use yet. As for Alelo, the style of their interactive, as well as mobile, training is certainly appealing – the question is if the program itself can be easily integrated.

3.2 Recommended Implementation of ITS Technologies into the IEDD Operator Course

The stakeholder meetings discussed the potential of adding an additional practice scenario to the IEDD Operator Course before the evaluations. This scenario would provide the ITS project team the opportunity to evaluate the impact of adaptive learning and intelligent tutoring technologies within the IEDD Operator Course. Specifically, the evaluation would both: (i) afford the ITS project team with an opportunity to fully-exercise a range of adaptive learning and intelligent tutoring technologies, and (ii) provide the greatest possible benefit to students on the IEDD Operator Course. This section presents a notional IEDD Operator Course ITS scenario and notional instructional design based on it.

3.2.1 Notional IEDD Operator Course ITS Scenario

The interpretation of the rules and procedures rely heavily on the situation assessment and decision-making activities undertaken in the field under considerable time pressure and stress. As such, students are often prone to decision-making biases. For example, previous academic research has shown that when people seek data to test their beliefs, they often select data that serves to confirm them (e.g. Confirmation Bias; Wason, 1960). Furthermore, despite having information that contradicts such beliefs, people are often very slow to change their minds (e.g. Belief Perseverance; Ross, Lepper and Hubbard, 1975).

Ideally, students will use the IEDD ITS on an individual and self-paced basis, in order for the ITS team to evaluate its utility for distance-learning applications. For example, the IEDD ITS can be used during the course itself, or as refresher training during exercises such as those pertaining to the ‘Road to High Readiness”. The requirements for the IEDD ITS scenario were discussed during the stakeholder meetings and were as follows:

- The scenario should be non-permissive. In other words, students should be under some degree of time pressure to conduct their threat assessment and plan their disposal strategies;

- The scenario should engender high levels of workload and pose a significant challenge to students in terms of the complexity of the threat assessment required in order to determine the correct RSP;

- The information available within the scenario (i.e., Situation Awareness ‘elements’) should be, on the surface, conflicting and ambiguous. However, closer inspection of these elements should resolve any conflicts and ambiguities. The intention is to promote a situation in which, on the surface, one particular

course of action is evident. However, if the student digs a little deeper into the information, contradictory information is found which *should* change their planned course of action. In other words, we seek to promote situations in which students might demonstrate 'confirmation bias' which affects their ability to change their planned course of action in light of contradictory information.

- The scenario needs to be realistic and relevant to current operational realities and complexities.

The content of the scenario itself was discussed, and the following section lists suggestions for its content:

- The scenario should be post-blast with a secondary device (victim-operated). The blast involved a CF convoy. No damage to vehicles or injuries to personnel were sustained.

- The following Non-Player Characters (NPCs) should be present:

    - <u>CF witnesses</u>. Students will interact with the CF personnel that observed the post-blast scene when conducting a dis-mounted patrol following the primary blast. These witnesses would have observed critical SA elements that the student must find out about. Ideally, all witnesses should be kept apart to ensure the objectivity of the witnesses.

    - <u>Afghan National Army (ANA) or Police (ANP) witness</u>. Students will interact with the ANA/ANP officer in charge who will speak for the ANA or ANP witness. Students should also be cognisant of cultural sensitivities when interacting with these types of NPCs. For example, some cultures might not want to readily admit to an authority figure that they do not know something, and will instead try to be helpful by being 'creative' with their answers. Again, this witness would have observed critical SA elements that the student must find out about. Finally, the implementation of the ANA or ANP witness should assume that the witness can speak English (or French) and does not require an interpreter NPC.

    - <u>Number 2 IEDD operator</u>. The Number 2 operator will act as an assistant to the Number 1, but will also be qualified as a Number 1; current operational practice is that IEDD operators will take it in turns to act as Number 1 when responding to IED incidents. As such, the Number 2 can be a source of information and advice. In terms of the ITS project, the Number 2 could be a source of hinting and coaching for the student. For example, the Number 2 can remind the Number 1 of critical SA elements.

    - <u>Quick Response Force (QRP) personnel</u>. Students will not necessarily need to interact with these personnel as part of their questioning, but they

should be present in the simulation. These NPCs could be used to manipulate the time pressure of the scenario.

- On Scene Commander (OSC). The OSC will be the first point of contact with the CF patrol on arrival at the scene of the post-blast. The OSC will brief the student about the situation and identify the witnesses for the student to question. The OSC is also responsible for coordinating the security cordon to protect both his/her personnel and those of the QRF and IEDD team. Similar to the QRF commander, the OSC can also be used to manipulate the time pressure of the scenario.

3.2.2 Notional IEDD Operator Course ITS Instructional Design

At present, the teaching of questioning technique (QT) consists of PowerPoint-based instruction on the knowledge and procedures relating to the determination of appropriate courses of action when disposing of IEDs and explosives. Course evaluation activities comprise of testing the students' retention of this knowledge using role-played evaluations with instructors.

Competence is often broken down into Knowledge, Skills and Attitudes (KSAs). The KSAs pertaining to the notional IEDD ITS scenario are as follows:

- *Knowledge*. Understanding of what factors need to be observed in order to classify the suspected device as either a command, timing or victim-operated device.

- *Skills*. Questioning technique of military and civilian witnesses.

- *Attitudes*. The personality trait of 'conscientiousness'. This personality trait includes such elements as self-discipline, carefulness, thoroughness, organization, deliberation (i.e., the tendency to think carefully before acting), and need for achievement.

Although we seek to improve the QT of students, it must be done within the context of the competencies required to execute the entire mission. For example, the effectiveness of the QT skills of the student will be a function of the knowledge of how that information should be used to assess the level of threat, and the conscientiousness of the student to persevere with questioning a difficult witness to get the information they need.

The next section describes the threat assessment and questioning technique components of the notional IEDD Operator Course ITS instructional design.

3.2.2.1 Threat Assessment

As previously discussed, in order for the IEDD operator to successfully dispose of the explosive device, it is critical that he or she accurately identifies the type of device so that the correct Render Safe Procedures (RSPs) can be used. The threat assessment process involves both the close inspection of the device itself and the gathering of information from third parties (e.g., civilians, local police, CF personnel etc) through questioning to determine the level of threat posed to personnel by the device.

This information can be couched in terms of Situation Awareness (SA) 'elements' (Endsley, 1995). Endsley (1995) argues that these elements (i.e., cues in the environment) must be perceived and understood by operator in order to decide on and initiate a successful course of action. These SA elements, together with existing knowledge structures (i.e., mental models) about the entities in the environment, form the basis of an operator's Situation Model of the environment.

In the context of the IEDD Operator Course, the threat assessment process is the means by which an operator forms their Situation Model of the suspected device. Specifically, the assessment as to what the suspected device actually is will be based upon an 'argument' formulated on the basis of the available evidence (i.e., SA elements). For example, evidence of a command wire will support the argument that the suspected device is command-operated, and so on. Arguments can also be conceptualised in terms of SA elements either supporting or objecting to the conclusion. For example:

- Conclusion #1: Suspected device is Command-Operated (or not)
    - <u>For</u>: presence of wire or transceiver, suitable observation or vantage point nearby, presence of an aim point (e.g., pile of rocks by roadside), previous insurgent activity at location, topography suitable for ambush (e.g., culvert, bend in road), minimal civilian presence.
    - <u>Against</u>: Busy route, well patrolled, civilians present, topography not suitable for ambush.
- Conclusion #2: Suspected device is Timer-Operated (or not)
    - <u>For</u>: predictable convoy, presence of timer, intelligence that VIP visits will occur, convoy passed but no activation, festival, religious holiday
    - <u>Against</u>: High levels of civilian activity.
- Conclusion #3: Suspected device is Victim-Operated (or not)

- For: Convoy passed but no activation, no presence of command, no Electronic Warfare (EW) detected, Intel that IEED are being targeted, primary device found,
- Against: busy, civilian activity (inadvertent activation)

An argument map is a visual representation of the structure of an argument in informal logic. It includes the components of an argument such as a main contention (i.e., final conclusion), premises (i.e., a set of one or more declarative sentences), and supporting information, such as co-premises (i.e., a reason arguing for a premise), objections (i.e., a reason arguing against a premise), and rebuttals (i.e., an objection to an objection). Typically an argument map is a 'box and arrow' diagram with boxes corresponding to premises and arrows corresponding to relationships such as evidential support. Argument mapping is often designed to support deliberation over issues, ideas and arguments that are difficult or impossible to solve because of incomplete, contradictory, and changing requirements that are often difficult to recognize.

An argument map has been created for a hypothetical IEDD scenario (see Figure 3-1) and represents the situation model of the operator. The threat assessment activities that took place in order for an operator to form this situation model include acquisition of SA elements through either direct observation or the questioning of witnesses. These SA elements either support or refute the higher-level premises or objections. The advantage of using this kind of approach is that it enables the IEDD Operator Course ITS to make explicit the results of the student's threat assessment process (i.e., their resultant SA). In doing so, comparisons between an 'ideal' Situation Model and the student's actual Situation Model can provide a mechanism for adapting the learning experience or as a focus for the instructor when de-briefing the student.

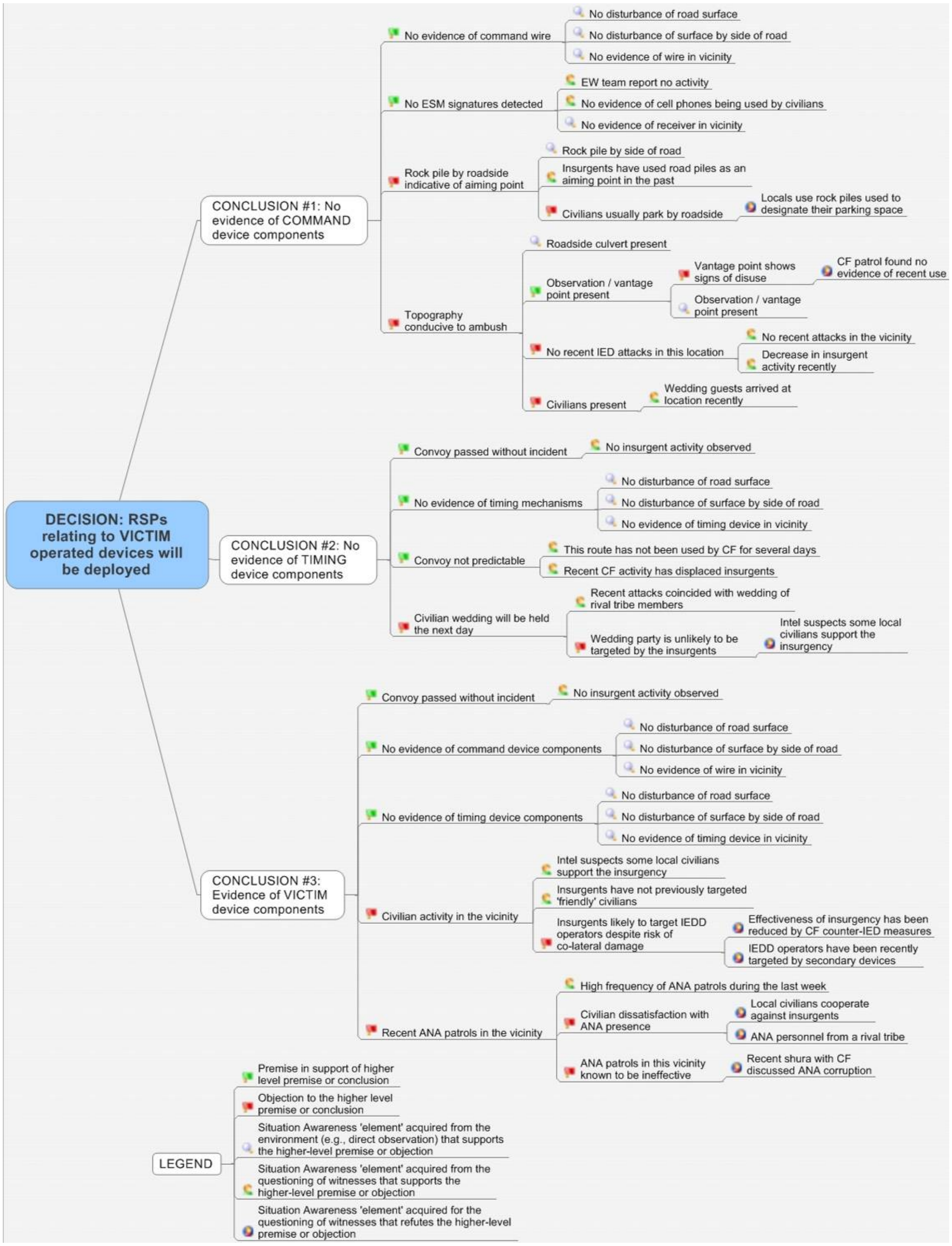


Figure 3-1: Notional Situation Model for the IEDD Operator Course ITS

3.2.2.2 Questioning Technique

Questioning Technique (QT) is the corner stone of IEDD operations. It enables the IEDD Operator to determine an appropriate Render Safe Procedure (RSP) to dispose of the device. For effective threat assessment, the IEDD Operator's best tools are active listening and questioning. Within the IEDD operations, questioning is used to:

- Begin or continue discussion;
- Pinpoint and/or clarify issues to gather pertinent information;
- Help/direct the witness to self explore; and,
- Keep focus on key issues;

Good QT will lead to more than one answer and open other avenues of questioning. Examples of good QT include (but are not limited to): funnel questioning, review questions, and cross-questioning; whereas examples of poor technique include: use of jargon and leading questions). For example, a hypothetical interaction between the IEDD operator student and a virtual On Scene Commander (OSC) within the simulated scenario would be as follows:

- <u>Student</u>: How are the civilians in this area?
- <u>OSC</u>: The local civilians are suspected to support the insurgency, although nothing concrete … yet. However, it is clear that they are uncooperative to CF.
    - SA Element: Local civilians may support insurgency.
    - Premise: Insurgents will not target local civilians directly.
- <u>Student</u>: Ok, and what's the deal with the decorations on that house?
- <u>OSC</u>: Their daughter is getting married tomorrow. There are lots of folks coming into town for this. It's been the talk of the town for the longest time. The father of the bride is a high-profile figure here. We suspect he has some links with the insurgency, but again nothing concrete.
    - SA Element: Higher levels of civilian activity in the area than normal.
    - SA Element: Father of the bride may support insurgency.
    - Premise: Insurgents are unlikely to target wedding party or guests.

Poor QT can also lead to confirmation bias insofar as the questioner only selects data that serves to confirm their beliefs; rather than seeks data to test them. Furthermore, despite having information that contradicts such beliefs, questioners might be very slow to change their minds (e.g. Belief Perseverance).

Within the IEDD ITS, the mission scenario can be created in a way that promotes the phenomena of confirmation bias and belief perseverance by providing easily-accessed information that at first seems to support one hypothesis, but also providing more difficult to access information that refutes that hypothesis. Using the situation model described in Figure 3-1, following an initial briefing that local civilians support the insurgency, and that insurgents have not targeted ‘friendly’ civilians in the past, the IEDD operator might deduce that the presence of civilian activity in the area reduces the likelihood that the suspect device is victim-operated. If this initial hypothesis remains unchallenged by conflicting data, the IEDD operator is likely to adopt RSPs applicable to either command or timer-operated devices.

However, there are other SA elements in the scenario which, if found, refute the premise that the presence of civilian activity in the area precludes the possibility of a victim-operated device. In this case, knowledge that the effectives of the insurgency has been reduced by CF counter-IED measures, and that IEDD operators have been recently targeted by secondary devices in this area should lead to the rebuttal that insurgents are likely to target IEDD operators *despite* the risk of co-lateral damage to civilians. This rebuttal should lead them to the correct conclusion that RSPs pertaining to a victim-operated device should be deployed.

These types of nuances within the scenario will be exploited to fully-exercise the range of QT skills that the student must possess in order to determine the correct RSP for the device, and the range of instructional interventions that can be initiated by the IEDD ITS.

3.2.2.3 Notional IEDD Operator Course ITS Hardware Configuration

Figure 3-2 describes a notional hardware setup for the IEDD ITS. It is anticipated that the IEDD ITS will be installed on a stand-alone computer with either a monitor (specification to be determined), and ancillary mouse and keyboard. Based on the minimum hardware requirements to run the VBS2 application and eye tracking software simultaneously, the hardware specification for the computer is as follows:

- Processor (CPU): 2.8 GHz Quad Core Processor
- Memory (RAM): 4GB
- Hard Drive: 80GB free space

- Video (Memory): 512MB Nvidia Video Card

VBS2 is designed to run on a wide range of Commercial-Off-The Shelf (COTS) computer systems readily available from many vendors. The graphics-intensive requirements however dictate special consideration to certain components such as the video card models configured in the system. Further information can be found at Bohemia Interactive's VBS2 website http://virtualbattlespace.vbs2.com

Figure 3-2: Notional hardware setup for the IEDD ITS

The IEDD ITS will utilise eye-tracking and psychophysiological tracking devices as inputs to the adaptation mechanism. The intention is that both these tracking technologies will be as unobtrusive as possible; in terms of their ease of set-up and configuration and their robustness to frequent use by course students. The technical specifications of these technologies remain to be determined; however it is anticipated

that both types of technologies will provide real-time data (i.e., gaze location and duration, and a numerical value of HRV[2]) to the ITS.

3.2.2.4 Notional IEDD Operator Course ITS User Experience

A notional IEDD Operator Course ITS user experience is presented in Figure 3-3 and illustrates the key components of the Graphical User Interface (GUI) in terms of both the presentation of training content and the means by which the student interacts with the IEDD ITS. The GUI is divided into the following components, which are described in relation to the notional GUI presented in Figure 3-3:

- *Simulated scenario environment*. Presented in the top left hand window of the GUI, the simulated environment is the primary means by which the student interacts with the scenario environment. This frame will display a 'first-person shooter' (FPS) view of the scenario environment, which will include terrain, vehicles, IED-related cues (e.g., wires, road patches, rock piles, and so on), as well as the scenario Non-Player Characters (NPCs). Students can navigate around the environment using the cursor keys on the keyboard. As with most FPSs, VBS2 takes over the mouse, and mouse motion moves the gaze around. The student cannot click on objects with the mouse. Instead, the selection mechanism in VBS2 is to approach the object and hit the 'enter' key or 'space bar' on the keyboard. For fine selection, the student alters their gaze with the mouse until the crosshairs in the middle of the screen is over the object, and then hits the 'space bar' or 'enter' key to make a selection. The NPCs are identified using a yellow arrow and a label. If a student wishes to question a witness, they need to walk up to the NPC and initiate the dialogue using the 'enter' key or 'space bar' on the keyboard. When the dialogue is initiated, the arrow above the NPC will turn red. After the dialogue is completed, the arrow will return to a yellow colour. Finally, the student will be able to click on relevant cues observed within the environment (using the crosshairs and the keyboard entry as described above) to activate them within the representation of their threat assessment (see below).

- *NPC Dialogue*. The dialogue with the NPCs is presented within the top right window of the GUI and is the primary means by which the student questions the scenario witnesses. This window displays a head and shoulders close-up of the NPC's avatar to enable any facial expressions (if provided by the supporting

[2] In order for the IEDD ITS to adapt the learning experience of the student in response to changes in their HRV data, we first need to determine the appropriate response 'thresholds' for these data. These thresholds will be unique to each student and are calculated from baseline data collected from the student under 'normal' resting-state (e.g., relaxed, unstimulated) conditions. In order to determine the threshold for what can be considered an 'affective response', the student needs to be presented with stimulus material appropriate to the scenario (e.g., photos of IED components or IED scenes, videos of IEDD operators conducting disposal and so on) during which HRV data are collected. The amount of change in the HRV data required to trigger an adaptation by the ITS can be calculated. In conclusion, the IEDD ITS should include a psychophysiological device calibration exercise, which could be performed under the auspices of a short introductory video or presentation outlining the project goals and the importance of threat assessment to successful IED disposal.

software) to be observed by the student. Each round of dialogue is presented in this window; however no history of the dialogue is recorded. This is to ensure that the student memorises the content of the dialogue; as in real-life. The dialogue will be turn-based insofar as the student will ask a question and the NPC will provide an answer to that question. Finally, the student will be able to select from a list of questions which one they would like to ask the NPC. The selection of questions is either keyboard-based (a numerical identifier is allocated to each option), or mouse-based (point and click on the option). The list presented in Figure 3-3 is for illustrative purposes only. Care will be taken during the development of this functionality to ensure that the list of questioning options does not constrain students' choices and pre-dispose them to adopting a particular questioning style. One option would be to present students the categories of questions (e.g., "questions about") and then provide a list of options for asking the same question but in different ways. This should allow students to exhibit their preference for a particular questioning style.

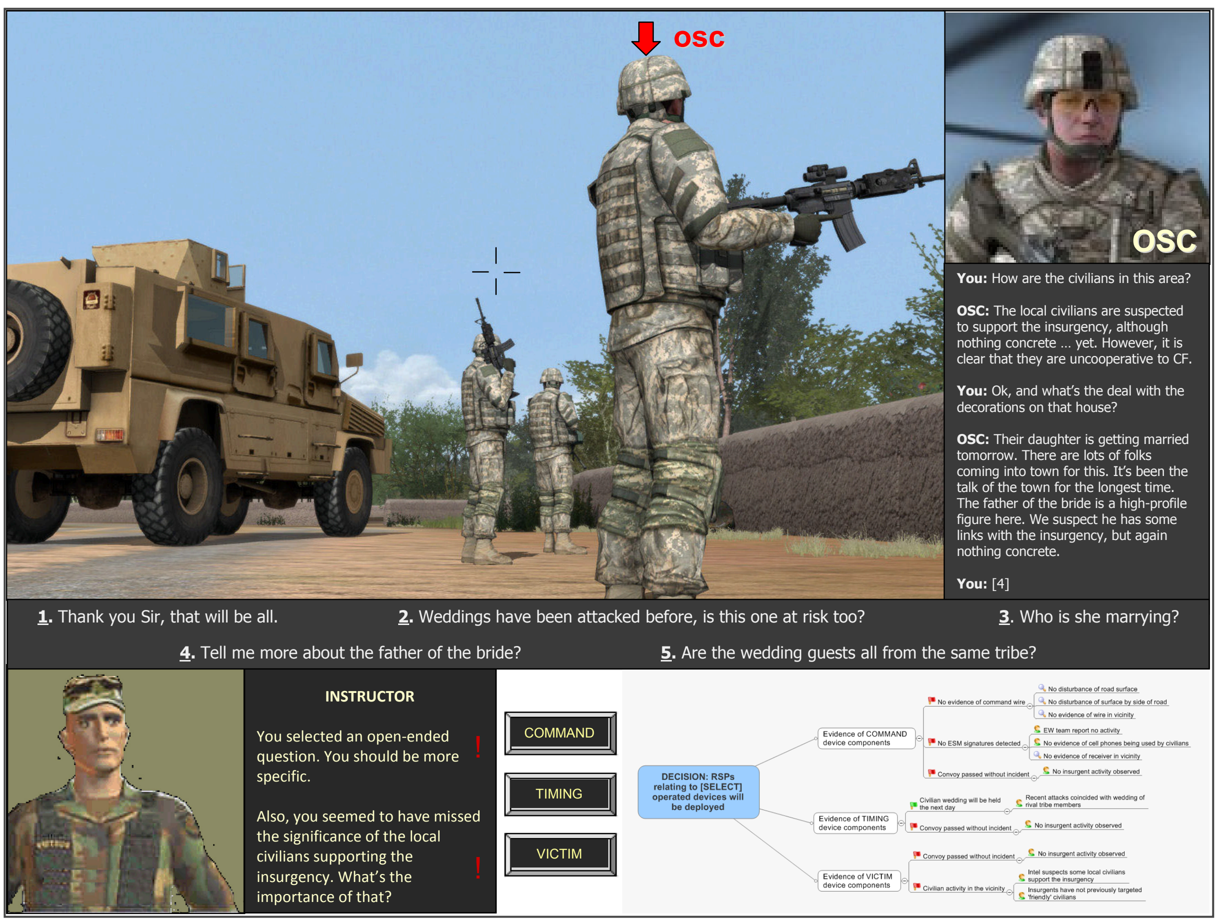


Figure 3-3: Notional IEDD Operator Course ITS User Experience

- *Threat Assessment (Situation Model Argument Map)*. As discussed in the previous section, we have proposed that an argument map is used to externalise the student's threat assessment and decision making processes when working through the IEDD scenario. The Situation Model Argument Map (SMAP) is presented in the bottom right window of the GUI, and provides a real-time depiction of the SA elements observed directly from the environment (as determined by the student's selections in the scene[3]) and the SA elements acquired from the questioning of witnesses (as determined by the content of the dialogue). SA elements acquired through direct observation will be automatically populated into the SMAP by the ITS. The SMAP will offer some degree of interactivity in terms of the student will be required to manually populate the SA elements acquired from the questioning of witnesses (e.g., click and drag the SA element to a premise or objection in the SMAP), and the construction of the higher order premises (or objections) derived from the SA elements. By forcing the student to make their deductions explicit, it is hoped that the ITS will be able to monitor the on-set of cognitive biases (e.g., confirmation bias). Finally, the student will have the ability to flag which type of device they currently believe the suspect device to be (i.e., command, timer or victim-operated). The student can make a final assessment of the device at any time they choose during the scenario. This effectively ends the scenario.

- *Virtual Instructor*. The interaction with the Virtual Instructor is presented within the bottom left window of the GUI and is the primary means by which the ITS explicitly coaches the student regarding their QT and threat assessment skills. As discussed before, the advantage of using the SMAP is that it enables the ITS to make comparisons between an 'ideal' Situation Model and the student's actual Situation Model. This knowledge provides a mechanism for adapting the learning experience. In addition, the Virtual Instructor will also have access to the eye-tracking data, mouse clicks on the scenario simulation window, and measures of the student's affective response from the psychophysiological tracking. This information could be used by the Virtual Instructor to 'hint' to the student that they might have missed key SA elements. For example, although the eye-tracking data might indicate that they were looking at an important visual cue (e.g., pile of rocks), a lack of a selection on the rock pile would suggest that they did not think it was important. Alternatively, when receiving an answer from a NPC which contains an important piece of information, a lack of affective response from the psychophysiological tracking would suggest that they did not think it was important (together with no attempt to update the SMAP with this SA element). In both cases, the Virtual Instructor would intervene, and hint that the student might want to revisit some of these cues.

[3] The project team will need to identify how to handle 'false alarms'; in other words, elements in the scene that were selected by the student, but are not considered to be relevant to the threat assessment. These data could provide insight into the deficiencies of a student's threat assessment technique (e.g., confirmation bias).

3.3 Recommended Architecture for the IEDD Operator Course ITS

Training systems and technologies are evolving to the point where the implementation of adaptive learning systems is possible. The results of the literature review seem to indicate that the increased training efficiency of adaptive systems more than offsets the increased cost and complexity of these systems. However, standards such as SCORM are still playing catch up to handle advanced training technologies such as simulation-based training and virtual world collaborative environments. DND enterprise learning systems such as DNDLearn and AFIILE do not currently support these evolving training delivery modalities. For this reason, it is strongly recommended that initial adaptive learning technology development should not be tightly coupled to the DND enterprise training systems as currently implemented.

Adaptive learning technology developments must be designed for eventual inclusion in systems such as DNDLearn and AFIILE. However, integration with these systems as they are implemented now will preclude, or limit, the use of many advanced training delivery modalities such as:

- Simulation environments that have specific hardware requirements for the training platform, such as graphics capabilities or human-computer interface devices;
- Simulation environments that have extensive data requirements, such as extensive, photo-realistic virtual terrains;
- Simulation environments that operate in networked, multiplayer modes;
- Tracking of student performance data in forms other than SCORM; and,
- Design and delivery of suggested notional learning interface that supports intelligent tutoring and adaptive capabilities.

Furthermore, it will be important that there are good channels of communication between the adaptive learning work and DND's learning system developers to inform the development DND enterprise's learning capabilities.

A three-stage process is recommended. First, an adaptive learning framework should be assembled. Second, learning content components of an electronic IEDD course should be developed. While future inclusion in a learning management system must be considered, these learning content components should not be limited to technologies currently compatible with DND's learning management systems. Finally, the IEDD learning content components should be integrated with the adaptive learning framework to produce a training delivery platform capable of performing experimental delivery of adaptive training using the electronic IEDD courseware components.

The adaptive learning framework should be a generic experimental framework that enables experimental training delivery with the potential to vary:

- The training content (course) delivered;
- The training content delivery type (text, imagery, multimedia, virtual simulation);
- The training content delivery style (individual, collaborative, instructor-led);
- The content adaptation mechanism (sequencing, pacing, complexity, type, learning style, etc); and,
- The component technologies used in the adaptation framework.

A notional architecture for the adaptive learning framework is given in Figure 3-4. The adaptive learning framework should incorporate learning content and student information management capabilities for experiment execution and data collection purposes. Architecture and design of the requirements of the adaptive framework should take into consider future integration potential with existing DND Learning Content Management and Learning Management Systems (LCMS and LMS).

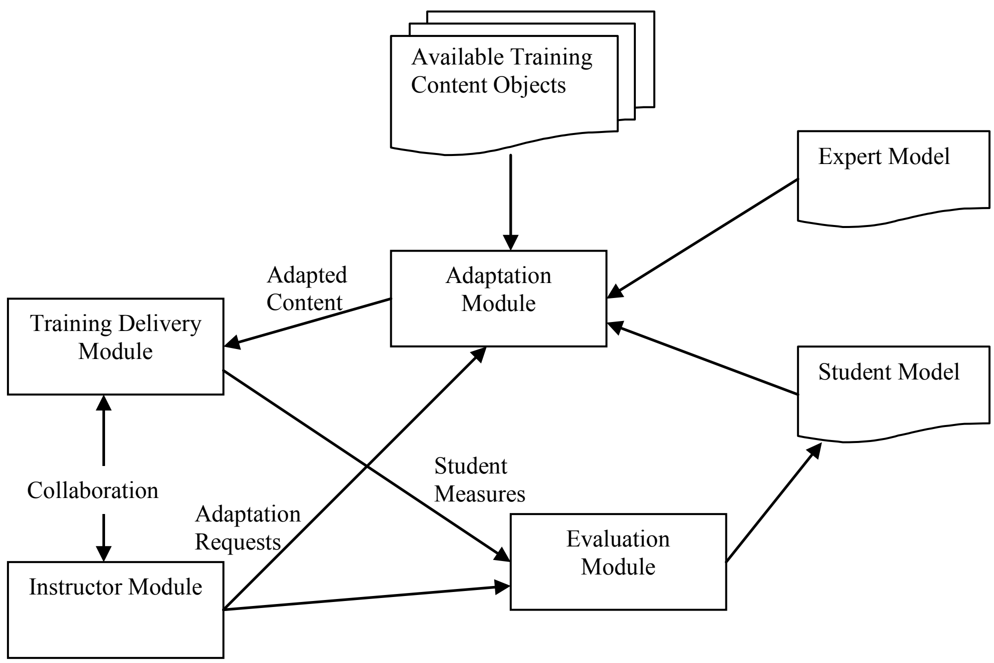


Figure 3-4: Conceptual architecture for an adaptive learning system (from Banbury et al., 2009)

The functionality required for the adaptive framework will be similar to the functionality within current DND LMSs. The adaptive learning framework should not be required to integrate with current DND LMS implementations, as this could potentially preclude the use of certain learning content types and delivery mechanisms. Rather, the format and standards involved with passing data between the systems will be considered during the design phase of the ITS project.

The components of the recommended adaptive learning framework are outlined below and detailed in the following sections:

- *Training Delivery Module(s)*. The purpose of the training delivery module is to present the training content to the student. This is the component of the system with which the student interacts. The training delivery module must be capable of presenting, at minimum: text-based content, multimedia content, individual virtual simulation content, and collaborative virtual simulation content. The presentation of training content is controlled by the adaptation module. The training delivery module must report outcomes and student interactions as required to the evaluation module. A training delivery module instance will be required for each student participating concurrently in a training experiment;

- *Evaluation Module*. The purpose of the evaluation module is to update the student model based on measurements of the student. The evaluation module must be capable of direct measurements of the student using physiological measuring devices, as well as indirect monitoring of student performance from user interactions reported by the training delivery module, such as key presses, timings, quiz results, and so on;

- *Adaptation Module*. The purpose of the adaptation module is to adapt the delivery of training based on the evolution of the student model. The adaptation module should examine the student model to adapt the delivered learning style to the evolving understanding of the student's learning style. The adaptation module must examine the difference between the student's grasp of the subject matter, the required understanding of the subject matter, and the expert representation in order to adapt any required aspects of the training delivery to improve the efficiency of the training delivery;

- *Expert Model.* The purpose of the expert model is to represent the knowledge, skills and/or behaviours that embody the desired end state of the student. The expert model must encapsulate, at minimum, the required proficiency of the student, and potentially the desired expert proficiency beyond that. The expert model is required, by the evaluation and adaptation modules, to evaluate the difference between the student's current state and the desired learning outcome. The expert model will not change during training delivery,

- *Student Model*. The purpose of the student model is to represent the current knowledge, skills and/or behaviours that embody the student. The student model will be updated during the delivery of training based on measurements of the student performed by the evaluation model. The student model may also require historical information on the student, such as learning history. The student model is required, by the evaluation and assessment modules, to evaluate the difference between the student's current state and the desired learning outcome;

- *Experiment Control Module*. The purpose of the experiment control module is to control the execution of the adaptive learning framework in a controlled fashion that collects the required data. The experiment control module will, at minimum, be required to provide initialization data (such as student history) as required by the various modules, and to collect experimental data as required from the various modules; and

- *Instructor Module(s).* The purpose of the instructor module is to allow the instructor to interact with the student(s) when requested by the student or instructor, or required by the training content. The instructor should be capable of participating collaboratively with the student(s) in the training content. The instructor should be capable of collaborating with the student outside of the training content in order to be able to coach or assist the student in an unstructured fashion. Depending on the course content, the instructor may be required to enter assessment information based on their assessment of the student's skill or performance. An instructor module will be required for each instructor involved in the experiment, as required by the training content.

- *Blackboard*. A blackboard system is an artificial intelligence application based on the blackboard architectural model, where a common knowledge base, the "blackboard", is iteratively updated by a diverse group of specialist knowledge sources, starting with a problem specification and ending with a solution. Each knowledge source updates the blackboard with a partial solution when its internal constraints match the blackboard state. In this way, the specialists work together to solve the problem. The blackboard model was originally designed as a way to handle complex, ill-defined problems, where the solution is the sum of its parts. Both the Experiment Control and the Instructor Modules could make use of Blackboards.

It should be noted that a limited adaptive learning framework can be constructed within a SCORM compliant LMS component at this time. In such a system, the components listed above are populated in the following fashion:

- The training delivery module is a standards compliant browser, and the training content is one or more SCO's limited to the multimedia content that can be displayed in a browser without any external software dependencies;

- The evaluation module is embedded in the SCOs and is reflected by the success or failure that the SCOs report to the LMS;
- The adaptation module is limited to the branching decisions that can be represented in the SCO sequencing information (for instance, remedial content can be presented if the student scores lower than a given standard on an intermediate evaluation);
- The expert model is limited to the lesson's success criteria (score) in the SCO sequencing information;
- The student model is limited to the lesson outcomes reported by the involved SCOs;
- The experiment control module is the containing LMS; and,
- Instructor module components for unstructured interaction with the student (such as chat, email, video conferencing) are sometimes provided by the LMS.

The adaptive learning framework is detailed further in the following sections.

3.3.1 Training Delivery Module

The purpose of the training delivery module is to present the training content to the student, and to manage the operator machine interface (OMI). The training delivery module should be based on a standard, 3D graphics capable PC with keyboard, mouse, headset with microphone, web camera and a single monitor. Other input devices such as joysticks and game controllers should be considered.

The delivery of training content is controlled by the adaptation module. The training delivery module must present the required content and report required student interactions to the evaluation module. As the training content selection is controlled by the adaptation module, the software presenting different content types can be treated independently, and may potentially be presented simultaneously (such as text to image reference material alongside virtual simulation-based practice). The required content types that must be supported during an experiment are determined by the course that is presented – the training delivery module must be capable of supporting the content types used in the electronic courseware. The following list defines content types that should be supported, and the recommended software applications:

- *Text, Images and Multimedia*. These content types should be delivered in a standards-compliant web-browser using standards-based browser technologies such as XHTML, videos, Adobe Flash and JavaScript. This content could be static or interactive, and might contain elements that explicitly evaluate the

student through structured quizzes. If possible, this category of content handling should be performed in a fashion that does not preclude SCORM compliance. At the time of this report, the recommended software for delivery of this content-type is Bohemia Interactive's VBS2. This software was selected in part due to its prevalence and availability within DND.

- *Immersive Virtual Simulation*. This content-type would include realistic, 3D simulation of a 3D space, such as the terrain and features surrounding the area of a reported IED location. The student might interact with this content-type individually or with other students and/or instructors. This content-type might be used for unstructured practice, structured learning or instructor-led learning. The student might be evaluated explicitly or assessed implicitly through their interactions with this content-type. The recommended software for delivery of this content-type is Bohemia Interactive's VBS2,

- *Non-Immersive Virtual Simulation*. This content-type would include the detailed, realistic simulation of an IED in isolation or in the context of the immediate environment at a nuts, bolts and wires level. The student might interact with this content-type individually or with other students and/or instructors. This content-type might be used for unstructured practice, structured learning or instructor-led learning. The student might be evaluated explicitly or assessed implicitly through their interactions with this content type. If possible, existing learning objects or other existing content will be identified and be re-purposed for this simulation. More specifically, DND has procured nGrain IED and bomb models. With some effort, these models may be able to be re-purposed. Furthermore, some types of IEDs may have a nGrain Virtual Task Trainer associated with them. This virtual task trainer often supports the functionality described above and should be integrated if possible rather than creating a duplicate function. Benefits and savings of re-purposing and integration efforts will be examined on a case-by-case basis. The recommended software for the delivery of this content type is nGrain's models. Should models not be suitable or if desired models do not exist, development of new models may be developed using nGrain technology or other readily available modeling technology.

The training delivery module must report outcomes and student interactions as required to the evaluation module. Where possible, this reporting process should align with the SCORM standard. An assessment of current and future SCORM standards should be considered.

Other supporting frameworks for student collaboration and student/instructor interaction should be considered when necessary by training course requirements. As these components do not integrate with the others of the adaptive learning framework, the selection of technologies is not critical. However, the following applications are recommended:

- Skype for video telephony;
- MediaWiki for unstructured text based collaboration and knowledge sharing; and,
- Access to standard email and text chat, with provisions for students and instructors who do not have or do not wish to use personal or business accounts.

The technologies outlined above have been selected to ensure focus on the adaptive engine and reduce concerns of licensing issues, and so on. It should be noted, however that these functionalities will become available through the DND enterprise integrated information learning environment. Integration of these future functionalities should be considered during design. A training delivery module instance will be required for every student participating in the training session.

3.3.1.1 High Level Requirements

For the IEDD course, the high level requirements for the Training Delivery Module are:

- Present 3D scene to student:
    - Allow navigation of scene;
    - Allow visual inspection of scene;
    - Show Non-Player Character (NPC) locations and actions;
    - Interaction with scene objects; and,
    - Show active elements of scene, such as people moving, and potentially device detonations.
- Allow questioning of NPCs:
    - Selection of NPC to engage in questioning;
    - Select questions; and,
    - Receive answers.
- Potentially allow ordering of NPCs:
    - Select NPC;
    - Select order; and,

   - Receive response.

- View current state of situation as described by the SMAP;
- Allow student to make deductions (correct or incorrect);
- Allow student to record observations (significant or insignificant); and,
- Present intelligent tutor coaching to the student in text, audio or multi-media.

3.3.1.2 Relationship with Other Modules

The training delivery module accepts input from the adaption module and produces output for the evaluation module. Key inputs for this module will be:

- Site data;
- Scenario event timeline;
- Question trees;
- Deduction tree/structure; and,
- Multimedia coaching packages.

Key outputs from this module will be:

- Student location and orientation;
- Student NPC selections;
- Student question selections;
- Student deductions; and,
- Student observations.

3.3.1.3 Recommended Implementation

In the context of the IEDD course, the training module enables the student's interaction with the IED site and the Non-Player Characters (NPC's) in the area. The student will navigate a 3D scene to observe and manipulate aspects of the site, and to select NPC's for questioning. Questioning will take place using a text based interaction, with the student selecting from predetermined questions representing a range of questioning

styles and a variety of topics wider than the IEDD focus. An element of the display will allow the intelligent tutor to provide coaching to the student.

The training delivery module is responsible for implementing the user experience outlined in Figure 3-4. Bohemia Interactive VBS2 is recommended to implement the 3D window for scene elements, navigation and selecting NPC's for interaction (in the upper left in the concept GUI). Alelo Virtual Role Players are recommended for further investigation to implement the NPC dialog functionality surrounding the 3D window. COTS multimedia display technology such as Adobe Flash is recommended for the presentation of the SMAP and the intelligent tutoring coaching material.

Bohemia Interactive's VBS2 provide a large library of equipment and scene items, and provide support for training goals relevant to the IEDD course, including:

- Assessing the scene;
- Enforcing scene safety;
- Evacuating personnel;
- Provide Command and Control (C2);
- Establish cordon;
- Establish ICP; and,
- Forensic evidence gathering.

VBS2 includes an extensive library of equipment and models, as well as content creation, scenario generation and after action review tools. Development will be required to interface the simulation environment into the adaptive learning framework, such that the evaluation module can make use of information from the simulation environment, and so that the adaptation module can control the execution of the simulation environment (see Figure 3-5 for an example).

Figure 3-5: A screenshot of existing immersive, virtual IED training material developed in VBS2

Alelo's Virtual Role Players for VBS2 allows instructors to populate VBS2 worlds with intelligent virtual role players, which communicate using spoken foreign language and exhibit culturally appropriate behaviour. VRP-VBS2 makes it possible to create highly realistic training environments in which students can practice their intercultural competency and foreign language skills, not just their kinetic warfighting skills. The avatar interaction approach and technology underlying Alelo's products should be investigated further to support the questioning technique element of the Training Delivery Module (see Figure 3-6 for an example).

Figure 3-6: A screenshot of existing Alelo cultural training within VBS2 (top left actions, top right output)

3.3.2 Evaluation Module

The purpose of the evaluation module is to update the student model based on measurements of the student. The evaluation module must be capable of direct measurements of the student using physiological measuring devices, as well as indirect monitoring of student performance from user interactions reported by the training delivery module. Due to the experimental nature of the recommended integration of physiological measurements with virtual simulation, the evaluation module will involve a significant proportion of custom development.

As measurement technologies and evaluation strategies will be a focus of the adaptive learning experimental plan, the evaluation module should be designed in a flexible, componentized fashion. Components that should be incorporated are:

- *Eye Tracking*. Eye tracking affords insight into the student's locus of attention. This information can be used by both the instructor and the system. The visual significance attributed by the student to features in a simulated scene can be compared to significances obtained from the training objectives or from tracking data recorded from subject matter experts.

- *Heart Rate Variability (HRV).* This technology can be used as an indicator of the students' level of excitement or relaxation.

- *Student Interaction Measures*. Information from the training delivery can be compared to knowledge of the training content to obtain measures of student proficiency, pace and behaviour. For example, a student who 's performance closely follows the expert path will likely accomplish tasks in the scenario in a timely fashion, use fewer on-line references if available, and perform tasks correctly in fewer attempts. Where possible, this information should be handled in a fashion that does not preclude SCORM compliance. However, the implementation limitations of SCORM around virtual simulation dictate that full SCORM compliance will not be possible.

The evaluation module must process the student's measurements into an assessment of the student state (workload, stress, proficiency, strategy employed, etc.) and use this information to update the student model. Due to the experimental nature of this process, it is likely that development will be required for this capability. Section 3.1 of this report reviews the results of parallel activities undertaken to review and identify adaptation mechanisms for adaptive learning and intelligent tutoring technologies (see Kramer, Tryan and Banbury; 2010). This section provides recommendations for the eye-tracking, psychophysiological indices of workload and stress, learning styles and performance tracking technologies.

The content delivery platforms detailed above (traditional e-learning, immersive simulation and non-immersive simulation) all contain provisions for proficiency assessment through measurements of performance objectives – scores on exams, completion of performance objectives and so on.

These standard methods of e-learning proficiency assessment can be included in the training content objects where suggested by the training needs analysis and pedagogical design. These methods provide feedback to the student and the adaptation module on how the student performed.

Further, the instructor module enables the instructor to provide feedback on the student. Beyond proficiency measurements, an instructor can normally provide insight into the reasons for the success or failure, and suggest corrected courses of action. This information is of high value to the student. Also, if this information can be captured in a fashion amenable to machine processing, it should be considered by the adaptation module as an adaptation input. This information can characterise why the student performed the way they did.

3.3.2.1 High Level Requirements

In the context of the IEDD course, the high level requirements for the evaluation module are as follows:

- Consolidate measurements of the student activities:
    - Answers received;
    - Locations visited;
    - Observations noted;
    - Deductions made;
    - Eye-tracking information (e.g., x, y position and dwell time); and,
    - Hear Rate Variability measurement.
- Produce observations that could have been made (using eye-tracking data);
- Correlate the heart rate variability information with the other observations to make deductions about the student state;
- Produce deductions that could be made from observations, information and domain knowledge;
- Compare logical deductions to student deductions; and,
- Update the student model.

3.3.2.2 Relationship with Other Modules

The evaluation module receives information from the Training Delivery module and produces information that is used to update the Student Model. Key inputs of the evaluation module include:

- Eye-tracker data;
- Heart rate variability measurement data;
- Student location data;
- Student answers received;

- Student observations noted; and,
- Student deductions.

Key outputs of the Evaluation Module include:

- Student observation accuracy;
- Student observation timeline;
- Student deduction accuracy; and,
- Student deduction timeline.

3.3.2.3 Recommended Implementation

The Evaluation Module has two key functions. The first is the correlation of the direct measures of the student (such as eye-tracking data) with indirect observations (such as the location of the student's avatar in the 3D world. This task is very specific to the eye-tracking system selected, and the 3D environment selected. The implementation of this functionality is largely expected to be custom development.

The second purpose of the Evaluation Module is to compare the deductions the student has made to the deductions the student *could* have made. Description Logic (DL) can model rational decision making and inference. Knowledge (facts and rules) in represented in ontologies provide a basis for making deductions. The evaluation module will make use of the ontology of IEDD knowledge, in conjunction with the observations that the student has made, to produce inferences on the deductions the student could logically have produced. The comparison of the logical deductions with the student's deductions produces an evaluation of the student's current state. The commercial DL reasoner, RacerPro[4] is recommended for this component of the evaluation module.

3.3.3 Adaptation Module

The purpose of the adaptation module is to modify the delivery of training based on the evolution of the student model. Mechanisms of adaptation should include:

- Adapting the pace of information delivery;
- Adapting the complexity of information delivery;

[4] The cost of RacerPro is between $2k and $10k depending on the license.

- Adapting the learning style focus; and
- Altering the selection of training content objects that are presented.

The adaptation module should offer a range of authority between adaptive systems (i.e., system-initiated adaptation) and adaptable systems (i.e., instructor-initiated adaptation). In some cases, the adaptation module should also provide advice to the instructor. For example, the adaptation module might suggest how the learning experience might be adapted to suit the specific needs of a student.

The adaptation module should accommodate the adaptation that is possible with the training content available for presentation. For example, if the training content in use does not provide multiple objects presenting similar information in different learning styles, adaptation based on learning style may not be possible.

The adaptation module is comprised of three functional components. First, the adaptation assessment component is responsible for producing system-initiated adaptation demands. Second, the instructor control component is responsible for handling instructor-initiated adaptation demands from the instructor module. Finally, the Adaptation engine must consider the adaptation demands, the available training content objects and the possible training object adaptations described in the metadata. From this, the adaptation engine controls the training delivery module in its delivery of the adapted content.

The adaptation assessment component must examine the student model and the expert model to produce adaptation demands. Some adaptation aspects will depend only on the student model. For instance, workload and learning style are two factors that influence adaptation, which depend only on the student model. Other adaptation demands will be based on the differences between the student model and the expert model. For instance, competency is assessed by the comparison of the student performance to expert performance and to performance standards captured in the expert model.

During instructor-led or instructor monitored training, the instructor may produce adaptation demands. The instructor control component coordinates these demands from the instructor module to the adaptation engine.

The adaptation engine is responsible for the translation of adaptation demands into changes in presented training content. First, the system-initiated and instructor-initiated adaptation demands must be balanced to place the system response in the desired range of the spectrum of adaptation (see Figure 12). Next, the consolidated adaptation demands must be compared to the available training content objects. Based on the metadata supplied with the training content objects, the adaptation engine then controls the delivery of training objects by the training delivery module, causing the delivery of training to be adapted to the student. Based on the capabilities of the training content

objects, this adaptation could be continuous during the execution of a training object, or there could be dynamic alteration of the sequence of training objects that are presented to the user.

The adaptation engine must be capable of utilizing the existing metadata that accompanies SCORM compliant SCOs. However, due to the limitations of SCORM, SCOs are a subset of the possible training content objects that this system must accommodate. As this stream of work will be developing the format of the other training content objects (such as virtual simulation scenarios), the development of the required metadata for these objects should be aligned with SCORM 2004 and the evolution of SCORM 2.0 where possible.

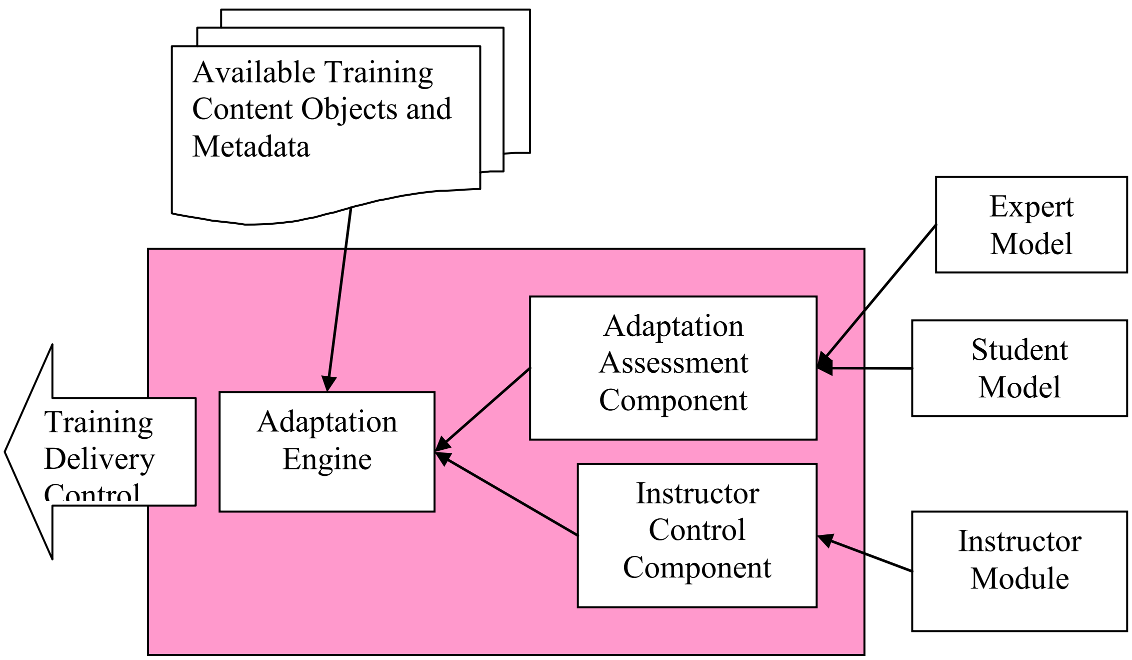


Figure 3-7: Notional architecture of the adaptation module

The electronic IEDD course design process will decompose the training material into a number of training content objects. Some of these will be SCOs, while some of these will be resources, models and scenarios for use in various simulation environments. A baseline course structure will be produced that sequences these training content objects into a teachable course.

When the training content objects are hosted in the adaptive learning framework, a range of adaptation options will then be possible during training sessions. The adaptation module can adapt the sequence of training content object presentation, the

complexity of simulation scenarios and the pace of simulation scenarios based on student measures and instructor adaptation requests.

Further, the training content objects can be hosted in an extended e-learning environment, such as the AFIILE LMS. Extensions to the LMS environment will be required to handle simulation-based content, which will not be SCORM compliant. In this environment, instructor-base adaptation is still possible through variation of training content object sequencing, and manual selection of simulation scenarios from a 'scenario library'.

3.3.3.1 High Level Requirements

In the context of the IEDD course, the high level requirements for the Adaptation Module include:

- Comparison of the student observations and timeline to an expert standard for observation;
- Comparison of the student questioning to an expert standard;
- Comparison of the student deductions and timeline to an expert standard;
- Comparison of student errors to error stereotypes;
- Selection of coaching material;
- Receiving coaching instructions from the instructor; and,
- Command the training delivery module to deliver required coaching

3.3.3.2 Relationship with Other Modules

The Adaption Module works with the Student Model and the Expert Module to produce commands to the Training Module. The Adaption Module also takes commands from the Instructor module: Key inputs to the Adaption Module include:

- Student events timeline;
- Expert representation; and,
- Error stereotypes.

The output from the Adaption Module is coaching commands for the Training Delivery Module.

3.3.3.3 Recommended Implementation

The Adaption Module will compare the Student Model (output from the Evaluation Module) to a model of expert performance to produce a performance measure for the student. The Adaption Module will compare the Student Model to common error stereotypes to potentially classify the student actions as belonging to a stereotypical error class. Based on these assessments, the Adaption Module will select appropriate coaching material for presentation to the student.

It is recommended that the Adaption Module uses the same ontology based reasoning approach as the Evaluation Module. RacerPro is the recommended reasoner. RacerPro is used as a system for managing semantic web ontologies based on Web Ontology Language (OWL). The design phase will confirm RacerPro's licensing model, costs and medium term capability to meet this requirement. At the same time, the technology watch task may consider a short evaluation of RacerPro's capability compared to other COTS reasoning engines. The deductive process for selecting appropriate coaching material will be represented in the adaption ontology. The reasoner will then act on this ontology in conjunction with the Student and Expert models to select appropriate coaching material. The design phase will confirm RacerPro's licensing model, costs and medium term capability to meet this requirement. At the same time, the technology watch task may consider a short evaluation of RacerPro's capability compared to other COTS reasoning engines.

3.3.4 Expert Model

The purpose of the expert model is to represent the knowledge, skills and/or behaviours that embody the desired end state of the student. The contents of the expert model are course-specific and static during the execution of a training session – the student and instructor interactions with the system do not alter the representation of the training objectives. The expert model must encapsulate at least two aspects of representation. First, it must encapsulate the required proficiency of the student as measured by the various training content objects of the course – the 'what' that the student must demonstrate to indicate successful training. Second, it must represent expert behaviours and skills – the 'how' that is used by the adaptive learning framework to provide feedback and adapt the training content to accelerate learning.

The SCORM standard specifies how SCOs encapsulate proficiency measures. The adaptive learning framework must make use of training content objects that are SCOs. For SCOs, the SCORM methodology for proficiency measures should be used as the basis of the proficiency standard of the expert model. For training content objects that

are not SCORM compliant, the SCORM methodology for proficiency representation should be followed, where SCORM technologies can represent the desired measures of proficiency. For any proficiency measures that cannot be represented within the SCORM standard, the representation used in the expert model should take into consideration the evolving SCORM 2.0 standard if relevant.

The representation of expert skills and behaviours will be highly dependent on the technology used to implement the adaptation module. The expert model is the profile of desired behaviour, used by the adaptation module to assess the student's competency. The expert skill and behaviour representation will also be populated in a fashion dependant on the adaptation module implementation.

The expert model is used by the adaptation engine to assess the student's state of competency during training delivery. The student model is compared to the expert model to assess the nature of the student's current deficiency, to drive the adaptation process.

In the context of the IEDD Operator Course, there are three relevant aspects to the expert model. The first aspect is a model of rational decision making with regard to IEDs and their disposal. The second aspect is a representation of the best practices for obtaining the information required for decision making, through observation of the scene, questioning of witnesses and investigation of the scene. Finally, the expert model should represent common errors and alternate learning paths.

The model of rational decision making pertaining to IEDD, based on argument theory, can be represented by an ontology. An ontology is a static data structure that represents the facts about IEDs, and the rules that allow deductions based on those facts. As previously discussed, this static data structure will be used by the Evaluation and Adaption modules to reason with the observations the student has made to logically deduce the conclusions the student should and should not be able to make. The ontology of IEDD is an expert model that allows the system to produce the conclusions an expert would be able to deduce from a given set of observations.

The second aspect of the expert model must provide guidance as to the priority and sequence of actions an expert would follow to produce the required observations. If the actions of an expert at IEDD can be defined procedurally, this information can also be represented as part of the IEDD ontology. If the actions and priorities of an expert operator are controlled by judgement, inference techniques or an artificial intelligence/pattern matching technique might be required to model this aspect of expert behaviour.

The World Wide Web Consortium (W3C) standardized Web Ontology Language (OWL) is recommended as the basis for the expert model. The CommonKADS templates provide guidance in the development of such an ontology, and the output of the recommended processes can be mapped to OWL ontologies.

3.3.4.1 High Level Requirements

In the context of the IEDD Operator Course, the high level requirements for the Expert Model are as follows:

- Represent decision making in IEDD;
- Represent priorities, sequences and procedures for IEDD;
- Represent common errors in IEDD reasoning; and,
- Represent alternate decision paths in IEDD procedures.

3.3.4.2 Relationship with Other Modules

The Expert Model is a static representation of expert behaviour. The Expert Model is referenced by the Evaluation Module and by the Adaption Module.

3.3.4.3 Recommended Implementation

For the prototype activity, it is recommended that the Expert Model be restricted to the aspects of proper IEDD that can be represented as a structured ontology. OWL is recommended as the standard for this ontology, due to the maturity of the standard, and the availability of tools to construct and reason with OWL ontologies.

3.3.5 Student Model

The purpose of the Student Model is to represent the current knowledge, skills and/or behaviours that embody the student. The contents of the Student Model are course and student specific, and evolve dynamically during the execution of a training session – the student’s interactions with the system updates the modelled state of the student’s competency.

Where possible, the Student Model should be partitioned into course independent information (such as learning style) and course specific information (such as competency). In an enterprise system, the course independent information should be stored in such a fashion that it can be reused in other interactions with the same student.

The course dependant component of the student model has the same composition as the Expert Model, other than the fact that it contains the current measure of the student’s state of competency, rather than the desired state.

The course independent component of the Student Model contains information such as learning style, user preferences and student background. This aspect of the student model should be populated, where possible, with historic information of the student, such as from an LMS or from previous student interactions. In certain cases, additional assessments may be required at the time of training delivery to initialize this component of the student model. For instance, if student learning style is a dimension of adaptation, and no information currently exists on the current student's learning style, a learning style quiz may need to be delivered as training preliminaries. Developing or refining this information using the measures of the student's interaction with the course specific learning content should be considered where possible.

The Student Model is updated during training execution by the Evaluation Module. The student's interactions with the system and performance in training content driven evaluations are used to update the training course specific aspects of the Student Model dynamically.

The Student Model is used by the Adaptation Module. The adaptation engine compares the current Student Model with the Expert Model to assess the student's deficiencies. This information is used to drive the adaptation process.

3.3.5.1 High Level Requirements

In the context of the IEDD Operator Course, the high level requirements for the Student Model are as follows:

- Represent the observations the student has made;
- Represent the actions the student has taken;
- Represent the decisions the student has made;
- Represent the learning style of the student;
- Represent the physiological state of the student (e.g., HRV data); and,
- Represent the attentional focus of the student (e.g., eye-tracking and interaction device data; such as keystrokes and mouse clicks).

3.3.5.2 Relationship with Other Modules

The Student Model is a dynamic store of information about the student. This data store is updated by the Evaluation Module, and is accessed by both the Evaluation and Adaption Modules.

3.3.5.3 Recommended Implementation

Due to the dynamics updates of the Student Model, and the potentially asynchronous access of the Student Model between both the Expert and Adaption Modules, a relational database implementation is suggested for the Student Model. Based on the information systems emphasis of the Adaption Module, Evaluation Module and any potential LMS, it is suggested that the implementation tool selection for the Student Model should be deferred until the detailed architecture is defined and the compatibilities and supported standards of the applications that must integrate with the student model are known.

3.3.6 Experiment Control Module

The purpose of the Experiment Control Module is to control the execution of the adaptive learning framework in a controlled fashion that collects the required data. The Experiment Control Module will, at minimum, be required to provide initialization data (such as student history) as required by the various modules, and to collect experimental data as required from the various modules.

The Experiment Control Module performs a role similar to the LMS in an enterprise training implementation. A modern LMS, such as the AFIILE LMS (e.g., Saba Learn), should be considered for this role. However, the capabilities of the LMS need to be considered from the perspectives of both supporting the experimental goals, and the advanced features of the training content and the adaptive learning framework.

It is expected that the experimenter will be able to make use of Blackboard functionality, as outlined in Section 3.3.8. The Experiment Control Module should include a Experimenter’s Blackboard to present the experimenter with relevant information.

3.3.6.1 High Level Requirements

In the context of the IEDD Operator Course, the high level requirements for the Experiment Control Module are as follows:

- Control the execution of the training system;

- Monitor the execution of the training system;
- Log relevant data for later analysis; and,
- Enable injection of experimenter comments and notes into the data log.

3.3.6.2 Relationship with Other Modules

The Experiment Control Module controls and monitors the execution of all of the modules of the system. It is expected that data for the experiment log will be drawn from all of the other modules in the system.

3.3.6.3 Recommended Implementation

Although it is anticipated that some kind of LMS will be used to implement the Experiment Control Module, it is suggested that the LMS tool selection for this module should be deferred until the detailed architecture is defined and the compatibilities and supported standards of the applications that must integrate with the Experiment Control Module are known.

3.3.7 Instructor Module

The purpose of the Instructor Module is to allow the instructor to interact with the student(s) when requested by the student, desired by the instructor or required by the training content. In this regard, the hardware and software configuration of the instructor module will be similar to the training delivery module. The instructor must be able to monitor or participate in the simulation-based training content to perform instructor-led or monitored training in these environments. As well, the instructor must be capable of collaborating and interacting with the student in an unstructured fashion to accomplish instructor-led training delivery.

The Instructor Module extends the training delivery module in that the instructor may be required to assess the student's performance with certain types of training content, and the instructor must be capable of executing instructor-initiated adaptation requests. The recommended implementation of the Instructor Module is a training delivery module with access to an instructor's interface of the Experiment Control Module. Finally, an Instructor Module will be required for each instructor involved in the training session.

It is expected that the instructor will be able to make use of Blackboard functionality, as outlined in Section 3.3.8. The Instructor Module should include an Instructor's Blackboard to present the instructor with relevant information.

3.3.7.1 High Level Requirements

In the context of the IEDD Operator Course, the high level requirements for the Instructor Module are as follows:

- Monitor the performance of the student;
- Inject coaching stimulus to the student;
- Inject scenario events into the training system; and,
- Control the progression of the scenario (such as pause functionality).

3.3.7.2 Relationship with Other Modules

The Instructor Module will monitor information from the Training Delivery, Evaluation and Adaption Modules in a fashion similar to the Experiment Control Module. The Instructor Module will also interact with the Adaption Module to initiate instructor-led adaptations or instructor initiated coaching sessions.

3.3.7.3 Recommended Implementation

Although it is anticipated that some kind of LMS will be used to implement the Instructor Module, it is suggested that the LMS tool selection for this module should be deferred until the detailed architecture is defined and the compatibilities and supported standards of the applications that must integrate with the Instructor Module are known.

3.3.8 Blackboard

A blackboard system is an artificial intelligence application based on the blackboard architectural model, where a common knowledge base, the "blackboard", is iteratively updated by a diverse group of specialist knowledge sources, starting with a problem specification and ending with a solution. Each knowledge source updates the blackboard with a partial solution when its internal constraints match the blackboard state. In this way, the specialists work together to solve the problem. The blackboard model was originally designed as a way to handle complex, ill-defined problems, where the solution is the sum of its parts.

A blackboard-system application consists of three major components:

1. The software specialist modules, which are called knowledge sources (KSs). Like the human experts at a blackboard, each knowledge source provides specific expertise needed by the application. The ability to support interaction and

cooperation among diverse KSs creates enormous flexibility in designing and maintaining applications. As the pace of technology has intensified, it becomes ever more important to be able to replace software modules as they become outmoded or obsolete.

2. The blackboard, a shared repository of problems, partial solutions, suggestions, and contributed information. The blackboard can be thought of as a dynamic "library" of contributions to the current problem that have been recently "published" by other knowledge sources.

3. The control shell, which controls the flow of problem-solving activity in the system. Within a blackboard system, KSs need a mechanism to organize their use in the most effective and coherent fashion. In a blackboard system, this is provided by the control shell.

3.3.8.1 High Level Requirements

In the context of the IEDD Operator Course, the high level requirements for the Blackboard are as follows:

- A library of the available knowledge in the environment (i.e., SA elements) accessed by:
    - Direct questioning of NPCs within the simulated environment; and,
    - Direct observation of cues (e.g. disturbance of road surface) within the simulated environment;
- The knowledge required to make each decision with the threat assessment process;
- The decisions required to complete the threat assessment process;
- Track the knowledge acquisition and decision making progress of the student in relation to a benchmark;
- Track the affective state (e.g., HRV data) of the student in relation to relevant SA elements; and,
- Track the eye fixation point and dwell time in relation to relevant SA elements.

Figure 3-8 provides an example of a blackboard which tracks (in real time) the following information pertaining to the student using the notional IEDD ITS user experience as described in Section 3.2.2.4:

- What knowledge in the environment (i.e., SA elements) has been acquired by the student (or not) from direct questioning of NPCs within the simulated environment (performance tracking);
- What knowledge in the environment (i.e., SA elements) has been acquired by the student (or not) from direct observation of cues (e.g. disturbance of road surface) within the simulated environment (performance tracking);
- Current threat assessment of the student in terms of which type of IED the student believes it to be (performance tracking);
- Current affective state of the student;
- Past affective state of the student in relation to relevant SA elements;
- Current eye fixation point and dwell time; and,
- Past eye fixation point and dwell time in relation to relevant SA elements.

3.3.8.2 Relationship with Other Modules

As discussed in the previous two sections, it is anticipated that the Instructor and Experiment Control Modules will both benefit from Blackboard-type functionality.

3.3.8.1 Recommended Implementation

Previous research conducted under the auspices of the United Kingdom's "Cognitive Cockpit" technology demonstration program (for a review see Banbury et al., 2007) developed a blackboard architecture to satisfy similar adaptation-based requirements to those of the IEDD ITS. The blackboard was implemented in an html format which all other modules were able to access. We suggest that the project team consult with experts from QinetiQ (Dr Blair Dickson) for advice on how the blackboard might be implemented for the IEDD ITS.

ITS Blackboard

SCENARIO STATUS	
Scenario type	Victim-operated IED
Time elapsed	HH:MM:SS
Current NPC Questioned	OCS
NPC Questioned (Total)	2 of 3
Data File	12345678_data.xls

STUDENT STATUS		
Student ID	12345678	
Learning Style	Visual dominant	Content-Vis#1
Affective State (/50)	45	High
Total % of SA acquired	General - 70%	Critical - 60%
Threat Assessment	Time-operated IED	Incorrect

NPC #1 QUESTIONING STATUS		
NPC #1	ANA Officer	
Questioned (Freq)	Yes (1)	
SA Element	*Description*	*Acq*
Acquired SA Element #1a	Wedding guests arrived	Yes
Acquired SA Element #1b	No cell phone activity	No
Acquired SA Element #1c	No recent attacks	Yes
Acquired SA Element #1d	Decrease in attacks	Yes
Acquired SA Element #1e	Weddings attacked	Yes
Acquired SA Element #1f	Civilians not attacked	No
Acquired SA Element #1g	High freq. of ANA partrols	Yes
Critical SA Element	*Description*	*Acq*
Acquired SA Element #1h	Roadside parking habits	Yes
Acquired SA Element #1i	Wedding guests arrived	Yes
Acquired SA Element #1j	ANA from rival tribe	No

NPC #1 INSTRUCTIONAL STATUS			
Main Teaching Point	*Description*	*Freq*	*Intervention*
MTP #1a	Closed question	0	CoachScript MTP #1a
MTP #1b	Cultural sensitivity	2	CoachScript MTP #1b
MTP #1c	Insufficient critique of answer	1	CoachScript MTP #1c
MTP #1d	Aware of importance	0	HintScript MTP #1a
MTP #1e	Leading question	4	CoachScript MTP #1d
MTP #1f	Not listening	0	CoachScript MTP #1b
MTP #1g	Jargon	2	CoachScript MTP #1f
MTP #1h	Negative question	3	CoachScript MTP #1g
MTP #1i	Not relevant	1	HintScript MTP #1b
MTP #1j	All SA elements acquired	No	HintScript MTP #1c

NPC #1 STUDENT QT PERFORMANCE	
% of SA Elements acquired	70%
% of Critical SA Elements acquired	66%
# of Questioning Errors	13

NPC #2 QUESTIONING STATUS		
NPC #2	OSC	
Questioned (Freq)	In progress (0)	
SA Element	*Description*	*Acq*
Acquired SA Element #2a	Recent CF activity displaced ins	Yes
Acquired SA Element #2b	No cell phone activity	No
Acquired SA Element #2c	No recent attacks	Yes
Acquired SA Element #2d	Decrease in attacks	Yes
Acquired SA Element #2e	No EW activity	Yes
Acquired SA Element #2f	Roadside culvert present	Yes
Acquired SA Element #2g	High freq. of ANA partrols	Yes
Critical SA Element	*Description*	*Acq*
Acquired SA Element #2h	IEDD operators targeted	Yes
Acquired SA Element #2i	Insurgency effectiveness down	Yes
Acquired SA Element #2j	ANA from rival tribe	No
Acquired SA Element #2k	ANA corruption	Yes

NPC #2 INSTRUCTIONAL STATUS			
Main Teaching Point	*Description*	*Freq*	*Intervention*
MTP #2a	Closed question	0	CoachScript MTP #2a
MTP #2b	Cultural sensitivity	0	CoachScript MTP #2b
MTP #2c	Insufficient critique of answer	1	CoachScript MTP #2c
MTP #2d	Aware of importance	0	HintScript MTP #2a
MTP #2e	Leading question	0	CoachScript MTP #2d
MTP #2f	Not listening	0	CoachScript MTP #2b
MTP #2g	Jargon	1	CoachScript MTP #2f
MTP #2h	Negative question	1	CoachScript MTP #2g
MTP #2i	Not relevant	1	HintScript MTP #2b
MTP #2j	All SA elements acquired	No	HintScript MTP #2c

NPC #2 STUDENT QT PERFORMANCE	
% of SA Elements acquired	90%
% of Critical SA Elements acquired	50%
# of Questioning Errors	4

NPC #3 QUESTIONING STATUS		
NPC #3	Trooper Smith (Witness #1)	
Questioned (Freq)	No	
SA Element	*Description*	*Acq*
Acquired SA Element #3a	No wire seen	
Acquired SA Element #3b	No road surface disturbance	
Acquired SA Element #3c	No reciever	
Acquired SA Element #3d	Roadside culvert present	
Critical SA Element	*Description*	*Acq*
Acquired SA Element #3e	Vantage point unused	

NPC #3 INSTRUCTIONAL STATUS			
Main Teaching Point	*Description*	*Freq*	*Intervention*
MTP #1a	Closed question		CoachScript MTP #1b
MTP #1b	Cultural sensitivity		CoachScript MTP #1b
MTP #1c	Insufficient critique of answer		CoachScript MTP #1c
MTP #1d	Aware of importance		HintScript MTP #1a
MTP #1e	Leading question		CoachScript MTP #1d
MTP #1f	Not listening		CoachScript MTP #1b
MTP #1g	Jargon		CoachScript MTP #1f
MTP #1h	Negative question		CoachScript MTP #1g
MTP #1i	Not relevant		HintScript MTP #1b
MTP #1j	All SA elements acquired	No	HintScript MTP #1c

NPC #3 STUDENT QT PERFORMANCE	
% of SA Elements acquired	
% of Critical SA Elements acquired	
# of Questioning Errors	

VISUAL SA ELEMENTS OBSERVED				
SA Element	*Description*	*Eye Tracker*	*Affective Response*	*QT Confirmation*
Acquired SA Element V1	No disturbance of road surface	Yes	No	Yes
Acquired SA Element V2	No disturbance of surface by side of road	No	No	No
Acquired SA Element V3	No evidence of wire in vicinity	Yes	No	No
Acquired SA Element V4	Rock pile by side of road	Yes	No	No
Acquired SA Element V5	Roadside culvert present	Yes	Yes	Yes
Acquired SA Element V6	Observation / vantage point present	No	No	No
Acquired SA Element V7	No evidence of timing device in vicinity	Yes	No	Yes

Figure 3-8: Notional contents of the ITS Blackboard

3.3.9 Summary of Technological Requirements for the IEDD ITS

Table 3-1 summarises the technologies required to meet the notional design of the IEDD ITS described in this report. In addition, any associated actions on the part of the CAE PS team to implement those technologies are described.

Table 3-1: Summary of Technological Requirements for the IEDD ITS

IEDD ITS Component	Technology Requirement	Action Plan
Training Delivery Module	XHTML, Flash, JavaScript, VBS2, nGrain, Alelo	Ensure licenses are in place / evaluate Aleo integration
Evaluation Module	Eye-tracking	Purchase EasyGaze
	HRV measurement device	Purchase HRVlive!
Adaptation Module	RacerPro	Evaluate alternative tools / acquire license
Expert Model	OWL compliant ontology	Use CommonKADS templates for guidance
Student Model	LMS	Evaluate LMS options
Experiment Control Module	LMS	Evaluate LMS options
Instructor Module	LMS	Evaluate LMS options
Blackboard	HTML	Seek implementation advice from QinetiQ

3.4 Recommended Implementation Plan for the IEDD ITS

The following section describes the tasks and schedule for the implementation and evaluation of the IEDD ITS.

3.4.1 Identification of IEDD ITS Development Route-Map

Banbury et al., (2007) developed guidance for the design and development of an Intelligent Adaptive System (IAS) based on information gathered during literature review activities about theoretical frameworks, analytical approaches, multi-agent systems, and the use of psychophysiological- and behaviour-based feedback. Their report highlighted the strengths and weaknesses of several design and analysis approaches, and created a development route-map for the successful development of an IAS (see Figure 3-9). The first step is to conduct a taxonomic analysis of the proposed system, followed by

the selection of the appropriate framework, analysis methodology, and design methodology. The final step is the selection of the appropriate design guidelines (in terms of principles of adaptation, interaction, etc.).

The following section describes each step in more detail, with particular emphasis on the selection of the most appropriate tools and methodologies for the IEDD ITS using the decision trees developed by Banbury et al., 2007.

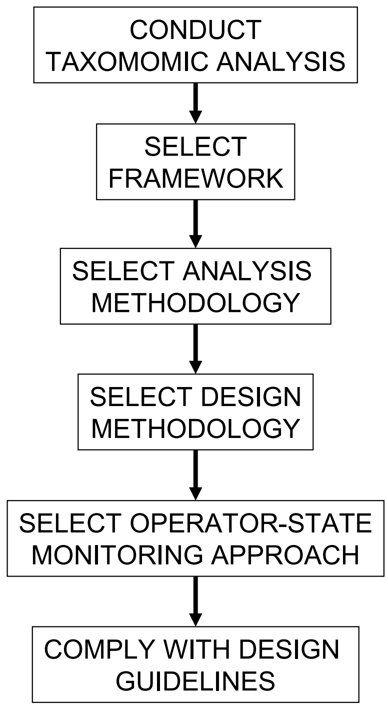


Figure 3-9: Development route-map for Intelligent Adaptive Systems (from Banbury, Gauthier and Scipione, 2007)

3.4.1.1 Conduct Taxonomic Analysis

Banbury et al., (2007) suggest that the development and implementation of intelligent adaptive systems can be guided by a taxonomic approach that scopes the options available for the capability and functionality of the system. In addition, a taxonomic approach can assist the creation of an audit trail for the design of the system. Finally, it can provide a road-map for development in that it allows the development team to focus on specific implementations after scoping all of the possibilities. Figure 3-10 describes a taxonomic analysis approach tailored to the requirements of the IEDD ITS.

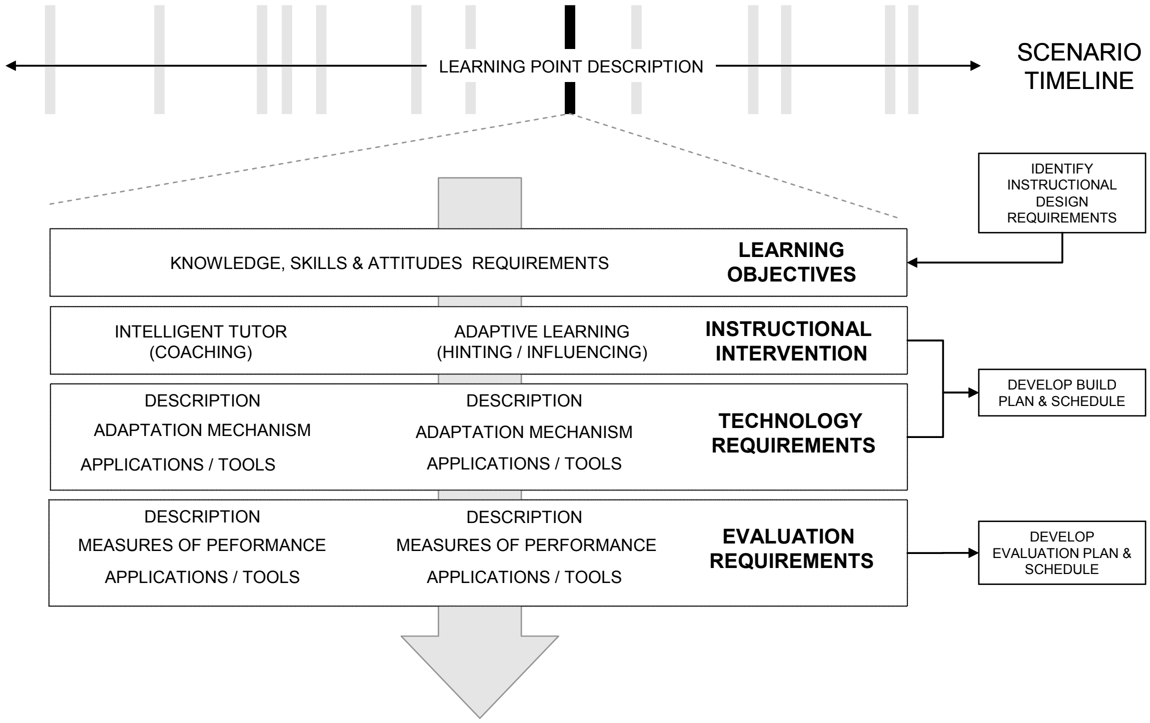


Figure 3-10: Notional taxonomic analysis framework for IEDD Operator ITS

In order to create the taxonomy for the IEDD ITS, the following factors need to be defined:

- The learning objectives (i.e., Main Teaching Points; MTPs) for each learning point in the scenario. The learning objectives can be broken down into the knowledge, skills and attitudes required to be judged as competent in that learning point;

- The instructional intervention required to teach or evaluate student competence for learning point. The instructional interventions can be broken down into adaptive learning (i.e., hinting or influencing) and intelligent tutoring (i.e., explicit coaching). The choice of instructional intervention should be determined by theories of learning and pedagogy. To date, traditional learning theories and educational paradigms have continued to be used to support distance learning. As learning technologies mature beyond page-turning Computer Based Training (CBT) and video demonstrations, a variety of learning approaches will have to be understood and integrated to achieve learning objectives and outcomes. This part of the analysis will briefly review learning theories that have been applied to novel learning technologies.

- The technological requirements needed to implement the instructional interventions identified for each scenario learning points. These interventions

should include the mechanisms for adaptation (e.g., eye tracking, psychophysiological response etc). Once again, the technological requirements can be broken down into adaptive learning and intelligent-tutoring technologies.

- The requirements for evaluating the utility of the adaptive learning and intelligent tutoring technologies for each learning point. These requirements should describe the measures of performance and the tools used. Once again, the evaluation requirements can be broken down into adaptive learning and intelligent-tutoring technologies.

In defining these factors, the taxonomic approach allows the instructional design to be explicitly identified for each learning point within the scenario, and through a specific adaptive learning or intelligent tutoring technology. The approach also allows the development team to construct an appropriate mission scenario which encompasses the range of system functionality and capability identified by the taxonomy. The mission scenario is used in both the subsequent analysis (i.e., as a precursor to the functional decomposition of tasks, goals and/or functions) and verification (i.e., determination of measures of effectiveness and performance) activities. Finally, the taxonomic approach allows the development team to quickly scope the functionality and capability of the IEDD ITS in terms priority and feasibility. This allows the development team to maximise the impact of the IEDD ITS on instructional operational performance whilst reducing development risk (e.g., due to dependence on immature technology) within the time and budgetary constraints of the project.

We recommend that the taxonomic analysis be conducted early during the next phase of the project in order to support the implementation of ITS technologies within the IEDD Operator Course.

3.4.1.2 Select Framework

The selection of an appropriate development framework affords the development team a number of advantages: reduction in development time and costs from leveraging previous research; benefit from the lessons learnt from past projects; and providing an insight into the potential operational impact of the developed system. One of the most recent and comprehensive attempts to generate a design and development framework for IASs was by Edwards (2004, and see Section 9.3.3 of Banbury et al.'s report). Edwards examined a variety of theoretical approaches to generate a generic, integrated and comprehensive framework for the development of an intelligent, adaptive, agent-based system for Uninhabited Air Vehicle (UAV) control.

We recommend the use of Edward's framework to support the development of the IEDD ITS. For example, we have already recommended the use of the CommonKADS methodology, as recommended by Edwards, for guiding the development of the Expert Model.

In addition, Banbury et al., (2007) provide advice for the selection of specific frameworks that may be used to guide the development process for a particular target domain (e.g., lessons learnt, appraisal of technological maturity). Their decision tree for the selection of design frameworks was completed for the proposed IEDD ITS (see Figure 3-11)

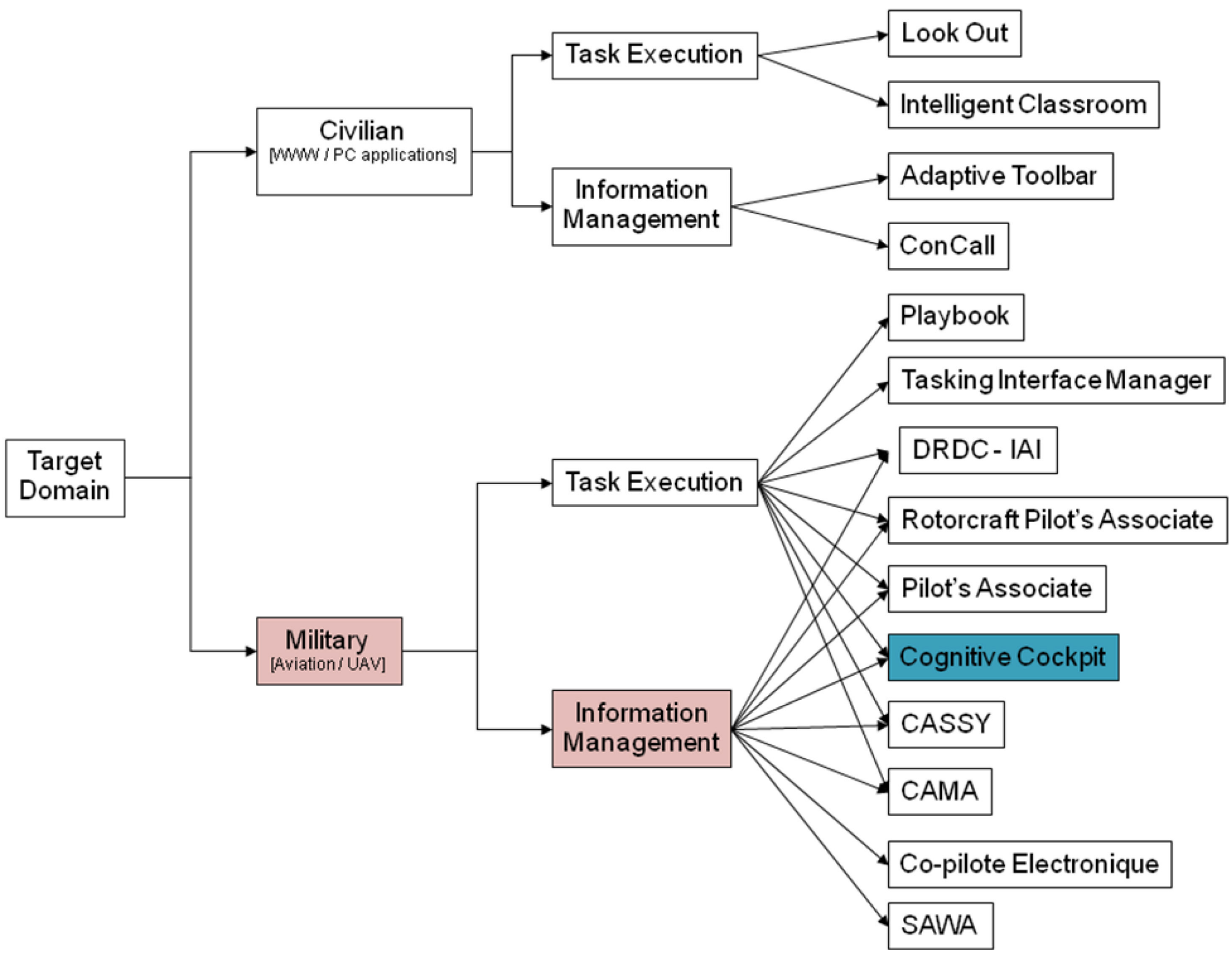


Figure 3-11: Decision tree for selection of design frameworks applicable to the IEDD ITS (from Banbury, Gauthier and Scipione, 2007)

We recommend that we take a closer look at the intelligent adaptive framework developed under the auspices of the United Kingdom's "Cognitive Cockpit" technology demonstration program (for a review see Banbury et al., 2007). For example, this project developed a blackboard architecture to satisfy similar adaptation-based requirements to those of the IEDD ITS.

3.4.1.3 Select Analysis Methodology

Analysis methodologies provide the GUI display and control requirements needed for the design of the IAS, as well as a functional decomposition of the tasks within the domain envisaged for it. In addition, analysis methodologies are also used as part of the training needs analysis to develop the instructional content for the IEDD ITS and populate the Expert and Student Models described earlier.

Banbury et al, (2007) provide advice for the selection of analysis methodologies based upon project constraints that may be used to guide the development process (e.g., lessons learnt, validation studies). Their decision tree for the selection of analysis methodology was completed for the proposed IEDD ITS (see Figure 3-12).

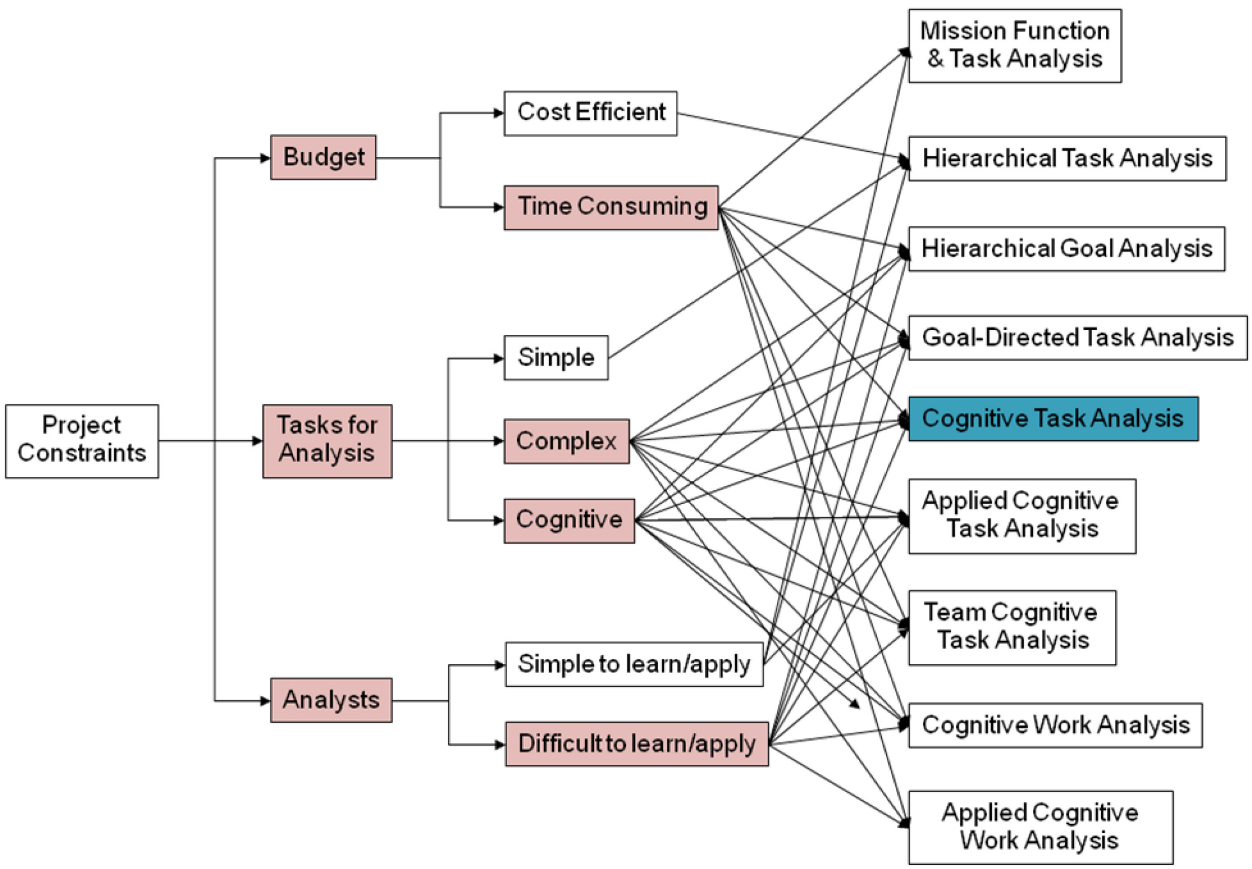


Figure 3-12: Decision tree for selection of analysis methodologies applicable to the IEDD ITS (from Banbury, Gauthier and Scipione, 2007)

Given the complexity and cognitive nature of the instructional material (i.e., threat assessment and decision making), the detailed knowledge capture requirements to implement an ITS, and the availability of expert analysts within the CAE PS project team, we recommend the utilisation of cognitive task analysis-based techniques to

develop the instructional content for the IEDD ITS and populate the Expert and Student Models.

3.4.1.4 Select Design Methodology

Design methodologies assist in the identification and definition of the knowledge required by intelligent systems. Banbury et al., (2007) provide advice for the selection of design methodologies that may be used to guide the development process of a particular target system (e.g., lessons learnt, validation studies). Their decision tree for the selection of analysis methodology was completed for the proposed IEDD ITS (see Figure 3-13).

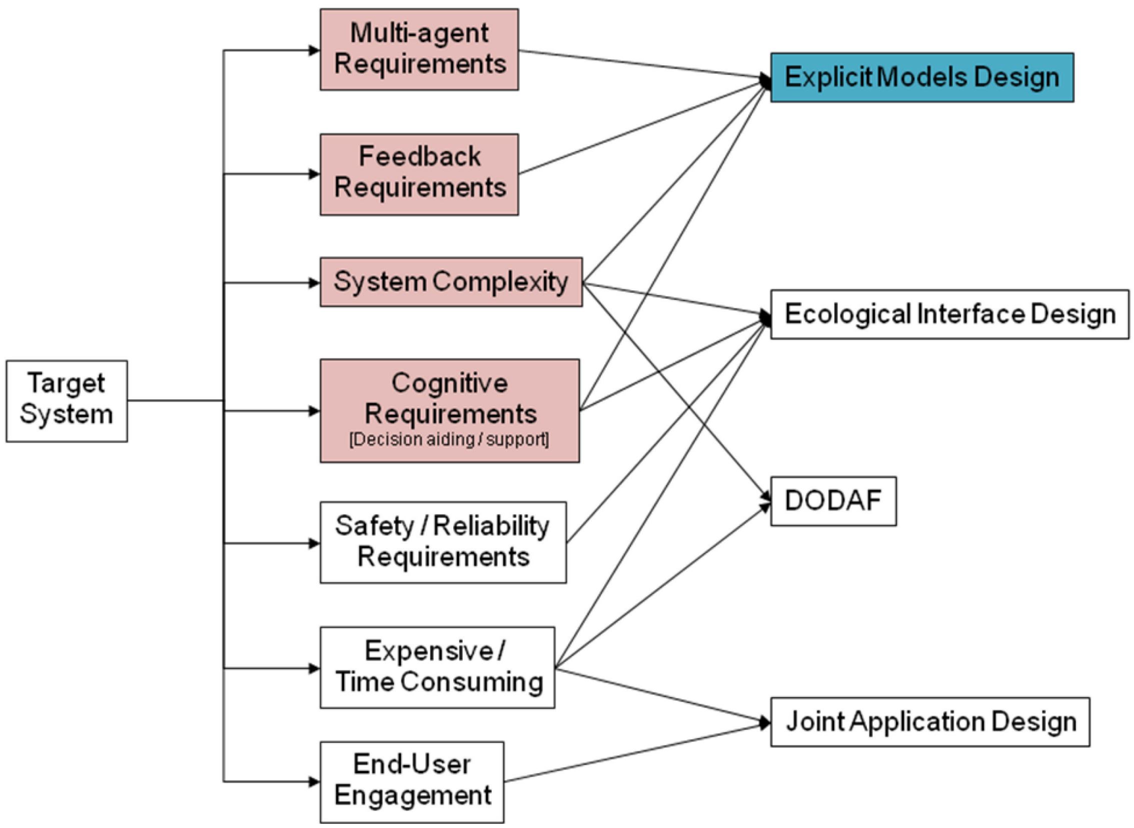


Figure 3-13: Decision tree for selection of design methodologies applicable to the IEDD ITS (from Banbury, Gauthier and Scipione, 2007)

Given the requirement for multiple agents, feedback, and cognitive-based instructional material, together with the complexity of IEDD scenarios, we recommend the use of Edward's (2004) Explicit Models Design to support the implementation of ITS technologies within the IEDD Operator Course.

3.4.1.5 Select Operator State Monitoring Approach

Operator state monitoring is, part, the mechanism by which the IEDD ITS will adapt the content and presentation of the learning material in order to optimise the student's learning experience. Banbury et al., (2007) provide advice for the selection of an operator-state monitoring approach that may be used to guide the development process of the target system (e.g., lessons learnt, appraisal of technological maturity). Their decision tree for the selection of analysis methodology was completed for the proposed IEDD ITS (see Figure 3-14).

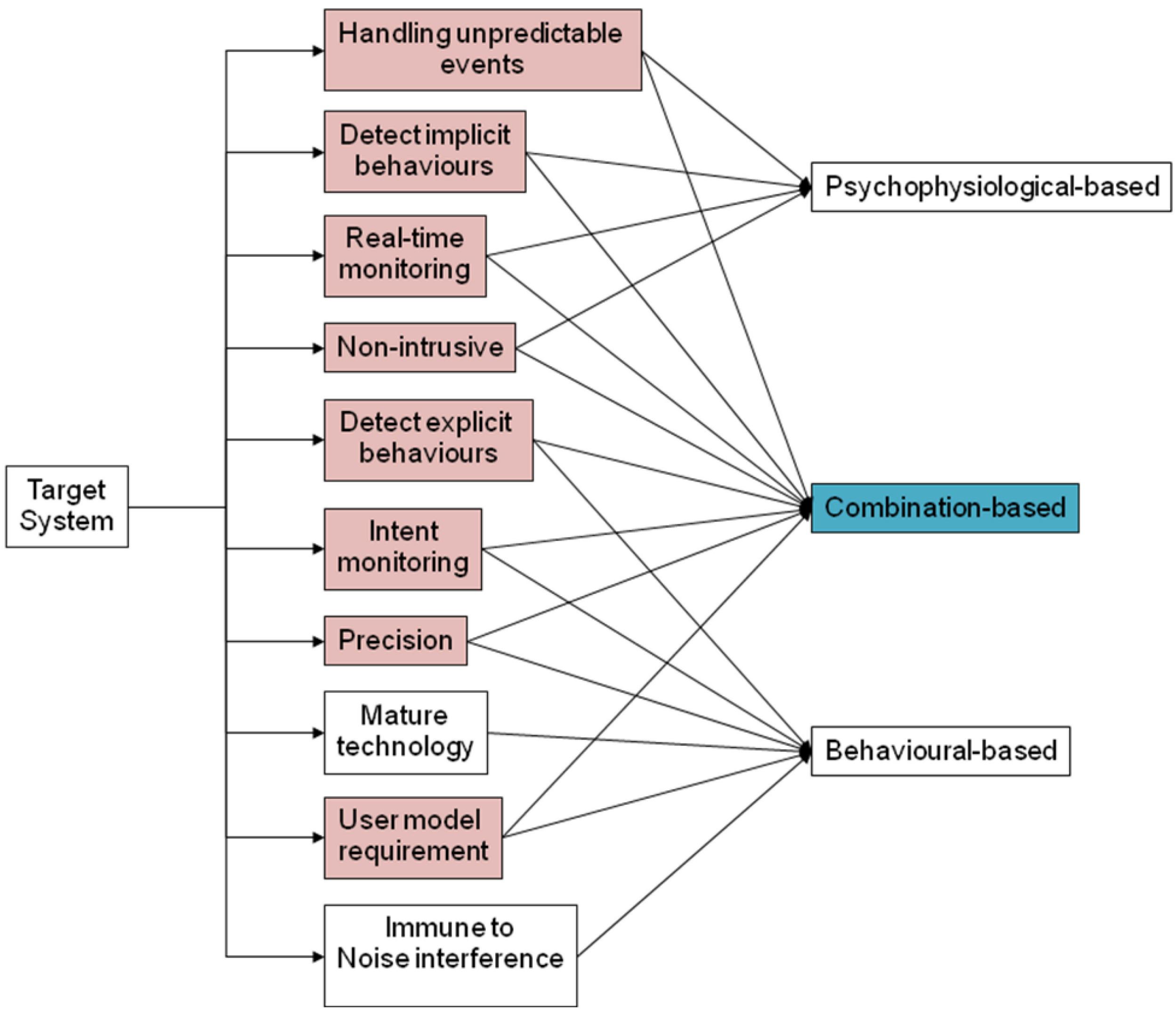


Figure 3-14: Decision tree for selection of operator state monitoring approaches applicable to the IEDD ITS (from Banbury, Gauthier and Scipione, 2007)

Kramer et al., (2010) provided an in-depth review of suitable psychophysiological-based and behavioural-based approaches to the monitoring of operator state, and recommended a combination approach utilising eye-tracking and HRV measurement to monitor operator state for the IEDD ITS. The results of the decision tree presented in Figure 3-14 are consistent with their recommendations.

We recommend that a combination-based approach to the monitoring of operator state; given that one of the objectives of the ITS project is to examine emerging operator state monitoring technologies in relation to their suitability to adaptive learning and intelligent tutoring approaches.

3.4.2 IEDD ITS Implementation Plan

This section lays out a work plan for implementing a working prototype of the IEDD ITS to enable its evaluation by students of the IEDD Operator Course. An iterative approach is outlined to push early integration of the proposed technologies. This enables early evaluation of a minimally functional system by the technical authority. This internal evaluation supports a more detailed prioritization of the functionality for the prototype. Due to resource and schedule constraints, this focus will be necessary to direct the prototype development effort.

The work plan defined in the following sections is divided into two iterations. The end state of the first iteration is a minimally-functional prototype for evaluation by the scientific authority. The purpose of this evaluation is to enable effective mid-point correction to the priorities of the technical development. The end state of the second iteration is the ITS prototype that will support the evaluation phase of the project. Within each iteration, the technical development will be scheduled around a monthly sprint structure that forces integration and evaluation on a monthly basis. The scope of potential ITS developments under consideration will likely exceed the schedule and budget available to develop and implement a prototype ITS within the IEDD Operator Course. The work plan described in the following sections describes the work to be performed to produce an ITS prototype to support evaluation as a component of the scheduled IEDD courses. Figure 3-15 provides an overview of the inter-relationships between tasks associated with the design, implementation and evaluation phases of the project. The remainder of this section will describe these phases in more detail.

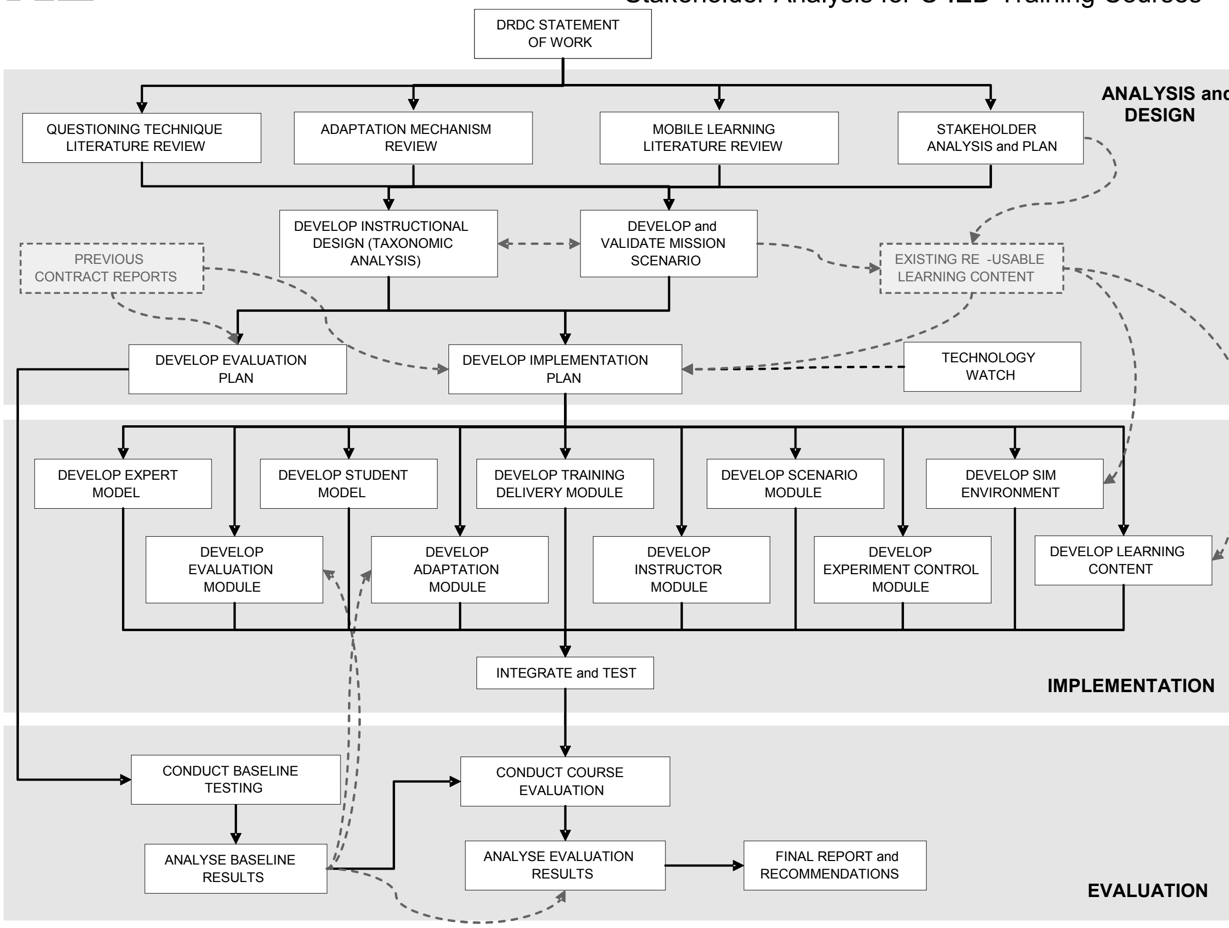


Figure 3-15: Overview of the inter-relationships between tasks associated with the design, implementation and evaluation phases of the project

3.4.3 Task Descriptions

This section provides a list of recommendations for tasks to be conducted early during the next phase of the project in order to support the implementation of ITS technologies within the IEDD Operator Course.

3.4.3.1 Questioning Technique Literature Review

In order to create new instructional material as part of the ITS scenario, a literature review of questioning techniques needs to be undertaken. The review should explore questioning and interviewing techniques used in qualitative psychology, doctor-patient interviews, police investigations (e.g., National Investigation Services). The review should also include cognitive biases that are thought to affect threat assessment and decision making (e.g., confirmation bias, cognitive tunnelling), and strategies by which questioners can adopt in order to mitigate them (e.g., problem solving and decision making techniques taught as part of aviation Crew Resource Management). The

intention is for these biases, and means to mitigate them, will be explored within the auspices of the ITS scenario. The review should also include any lessons learnt from the meeting with Maj Terfry at the School of Military Intelligence (CFB Kingston) concerning the Tactical Questioning course, and Dr Bruce Spencer at the Institute for Information Technology (NRC, Fredericton) regarding the adaptive learning system for doctor-patient interviews. Finally, the review should also seek to identify the causes of failure of IEDD Operator Course students. Correlates to be examined should include existing psychometric data collected during enrolment into the CF. This work should be completed in collaboration with the relevant personnel at NDHQ who would provide the necessary data.

3.4.3.2 Develop and Validate IEDD ITS Mission Scenario

The second task is for the human factors and technical team to work together to flesh out the current experimental concept into a detailed storyboard of the IEDD ITS scenario. The storyboard will serve as the requirements specification for the prototype. However, an agile philosophy is recommended – the purpose of the storyboard is not to unambiguously specify the functionality of a clearly defined system – rather, the purpose of the storyboard is to clearly communicate the functionality of the desired prototype system between the scientific authority, and the CAE PS Human Factors and Modeling and Simulation teams. The storyboard should define more functionality than is expected for the prototype, and should prioritize functionality. This information will allow the team to balance scientific/experimental significance with technical complexity to produce the most effective prototype possible given the fixed schedule and budget constraints. It is expected that the storyboards will evolve over time as the developing prototype is evaluated and insights gained are fed back into the storyboard-based definition of the system.

The storyboard should use simple artefacts such as cue cards, PowerPoint style graphics and simple text to outline the script for the IEDD ITS scenario in detail. The storyboard should explore the option paths. The storyboard provides the development team with a picture of the system that needs to be built, and makes explicit what the technical prototype must accomplish. The storyboard also provides the basis for negotiation and refinement within the team as strengths and limitations of technology are encountered.

An initial storyboard will be developed at the start of the next phase of the ITS project. The storyboard will be a living document that will be refined and modified as the prototype is iteratively developed. The initial storyboard will developed during a scenario development and instructional design workshop. This workshop will support the development of a suitable mission scenario for the implementation of ITS-related technologies into the IEDD Operator Course. This should be held in May 2010 at the School of Military Engineering, CFB Gagetown to coincide with a visit to the Spring

2010 IEDD Operator Course. This workshop will also develop ITS training and evaluation scenarios based on the mission scenario. Specifically, Main Teaching Points (MTPs) will be developed for the following Performance Objectives (POs) from the Qualification Standard (QS) Improvised Explosive Device (IEDD) Operator (reference: A-P3-002-IED/PH-H01): PO 5.10 Good Questioning Technique, and PO 5.11 Task Appreciation / Threat Assessment. Finally, evaluation criteria for these POs will also be developed.

Next, the data, information and knowledge required to support the experimental scenario must be made explicit. An initial knowledge representation must be developed at the initiation of the technical work. However, this task is expected to continue in parallel with the technical development over the course of the development of the prototype. Knowledge must be represented in a number of areas:

1. The central knowledge representation is the ontology of IEDD knowledge. This ontology must classify and decompose IED devices. It must define the render safe procedures. It must relate the classification of devices to the render safe procedures. It must define the observations of the environment that relate to deducing device characteristics. Finally, it must make explicit the inference rules that are used to relate the observations of the environment to the deductions about the device characteristics.

2. The second knowledge representation required is the definition of the question and answer structure. Certain of the observables defined in the IEDD ontology are mapped to answers that specific NPC characters in the simulation could provide to the student. The question and answer structure must make explicit which NPC's can make available which answers, and what questions are required to elicit these answers. It is expected that this structure will also contain questions and answers not directly related to the IEDD deductive process, as part of the student's workload is the separation of information into items related to IEDD, and items note related to IEDD.

3. The third knowledge representation required is the mapping of the remaining observations to items discoverable in the simulated environment. This provides the requirements for what items need to exist in the simulated environment to support the IEDD task. Further, it is expected that additional items will be specified, as part of the student's workload is the separation of observations related to IEDD from observations that are not crucial to the task at hand.

4. The fourth knowledge representation required is an ontology of the dynamic elements required to support the experimental scenario. For instance, if student or NPC actions can cause IED detonations, or if student actions can cause NPC actions such as departure from the scene, this ontology must define the possible actions, and the rules by which these actions are triggered.

The technical development will be dependent on the format in which these knowledge representations will be captured. The initial effort of the CAE PS Human Factors and Modeling and Simulation teams will be the definition of this standard. The population of these knowledge representations can then proceed in parallel with the technical development.

3.4.3.3 IEDD ITS Development: Iteration 1

The purpose of the first iteration is to produce a minimally functional implementation of the ITS prototype to allow early evaluation to focus priorities for the second iteration, to assess risk in areas of unknown complexity, and to allow early validation of the system concept. The first iteration will itself be composed of four sprints through the activities listed in the following sections. Each sprint is one month long and cycles through definition, design, development, integration and test. This iterative structure develops technology in a fashion that quickly develops a clear picture of progress and risk. This structure enables early review and feedback from the scientific authority and the SME community. This form of iterative development may be less appropriate for the development of a larger, well defined system, but works well for the rapid development of a prototype for experimentation.

Iteration 1 will be composed of four sprints, each composed of four sequential work tasks. These work tasks are defined in the following sections. The early sprints will be weighted towards the specification and definition activities. The later sprints will be biased towards the development, integration and test activities.

3.4.3.3.1 Sprint #1-1: Specify Storyboards and Knowledge Representation

As described in the previous sections on the Storyboarding and Knowledge Representation tasks, the technical development is dependent on the understanding of the system requirements as detailed by the storyboards, and on the nature of the supporting data in the form of the knowledge representations that will support the operation of the system. Each sprint will select a focus in the functionality defined in the storyboard and use this focus as the basis for the development effort of that sprint.

3.4.3.3.2 Sprint #1-2: Define System Module and Interfaces

Next, the functionality that is the focus of the sprint will be used to refine the system concept. The initial system concept is outlined in Section 3.2 of this report. The first stage of work for this task is to assign the functionality to the modules defined in the system concept. Next, the interfaces between the modules will be defined/refined based on the allocation of functionality. This will allow the development of the modules to proceed in a more loosely coupled fashion.

3.4.3.3.3 Sprint #1-3: Develop Modules

Next, the functionality assigned to each module must be implemented. Early sprints will focus on the selection of supporting COTS/GOTS technology and tools to provide as much of the required functionality as possible. Later sprints will focus on the extension of these tools to provide required functionality, or the development of new functionality and interface implementations where required.

3.4.3.3.4 Sprint #1-4: Integrate and Test

The final stage of each sprint is the integration of the new developments into a functioning system and the testing of this system. Typically a level of integration is pushed during the development phase, but the final integration and test activity in each sprint provides a more structured activity to:

1. Verify that the system concept provides the required functionality;
2. Verify that the selected tools and technologies operate as expected, and
3. Allow informal review of the developing system by the scientific authority and by SME's to provide early validation that the system concept and storyboards are a good representation of the end user needs.

The Integration and Test phase of the last sprint of the first iteration will be a more formal evaluation of the system. If SME availability is limited, SME involvement should be focused on this integration and test phase.

3.4.3.4 IEDD ITS Development: Iteration 2

At the initiation of the second iteration, the first iteration has produced a minimally functional prototype that has been tested and reviewed. At this point, the system storyboards and knowledge representations will have been refined, and the detailed experimental plan should be available. The initiation of the second iteration provides an opportunity for the scientific authority and for the project team to review the progress to date, the functionality of the initial prototype, and the utility of the selected tools and techniques for the project objectives. This review will provide an opportunity to refine the project objectives and provide clarity to the technical priorities for iteration 2.

The second iteration will follow the pattern of the first iteration. The second iteration will be composed of four sprints, each one month in length. The objective of the second iteration is to develop the ITS prototype that will support the experimental plan. The first three sprints are identical to the first iteration; whereas the scope of the fourth sprint (Evaluation) is described in more detail below.

3.4.3.4.1 Sprint #2-4: Evaluate Prototype

The Test and Evaluation phase of the last sprint of iteration 2 will be a formal evaluation of the ITS prototype. This final evaluation will allow the scientific authority to verify that the prototype supports the evaluation plan, and to validate that the developed functionality addresses the objectives of the ITS project. The outcome of this evaluation is a clear picture of the fitness of the prototype to support the project's evaluation objectives. The evaluation plan for the IEDD ITS is described in more detail in Section 4 of this report.

3.4.3.5 Technology Watch

Given the rapid pace at which gaming, and modeling and simulation-based technologies are evolving, it is important that the ITS project is aware of the current state-of-the-art of both modeling and simulation technologies, and adaptive learning and intelligent tutoring technologies. In addition, it is also important for the ITS project to maintain and strengthen the relationships with the stakeholders established during the first phase of the project. An ongoing task during the next phase of the project will therefore be a Technology Watch.

3.4.4 Provisional Schedule for IEDD ITS Implementation and Evaluation

The following section describes a provisional schedule for the implementation and evaluation of the IEDD Operator Course ITS. The schedule is driven by a number of factors. Specifically:

- The project will be completed by 31st March 2012.
- The evaluation of the IEDD ITS will be scheduled to coincide with the running of the IEDD Operator Course at CFB Gagetown. The course is run three times per year; generally the spring, summer and fall. In order to capitalise on these opportunities the following evaluation activities are scheduled[5]:
    - Mission scenario workshop. Development and validation of IEDD ITS mission scenario and taxonomic analysis. To coincide with the spring 2010 course. Further opportunities to refine the scenario and analysis will coincide with the summer and fall 2010 courses.
    - Baseline data collection. Administration of questionnaires and collection of baseline psychophysiological data from course students will coincide with

[5] The evaluation plan for the IEDD ITS is described in more detail in Section 4 of this report.

the spring 2010 and spring 2011 courses. This provides a total of approximately 40 participants (20 per course).

- Prototype evaluation. A dry-run with course students and instructors in order to get feedback regarding the usability of the IEDD ITS and the quality of instructional feedback. The prototype evaluation will coincide with the spring 2011 course.

- ITS evaluation sessions. The formal evaluation of the IEDD ITS with course students will coincide with the summer and fall 2011 courses. This provides a total of approximately 40 participants (20 per course).

Figure 3-16 presents the provisional implementation and evaluation schedule for the IEDD ITS. The schedule is driven, in part, by the six IEDD Operator Courses to be run in 2010 and 2011. The IEDD development and evaluation spirals, as well as the data collection activities, have been scheduled to coincide with these courses.

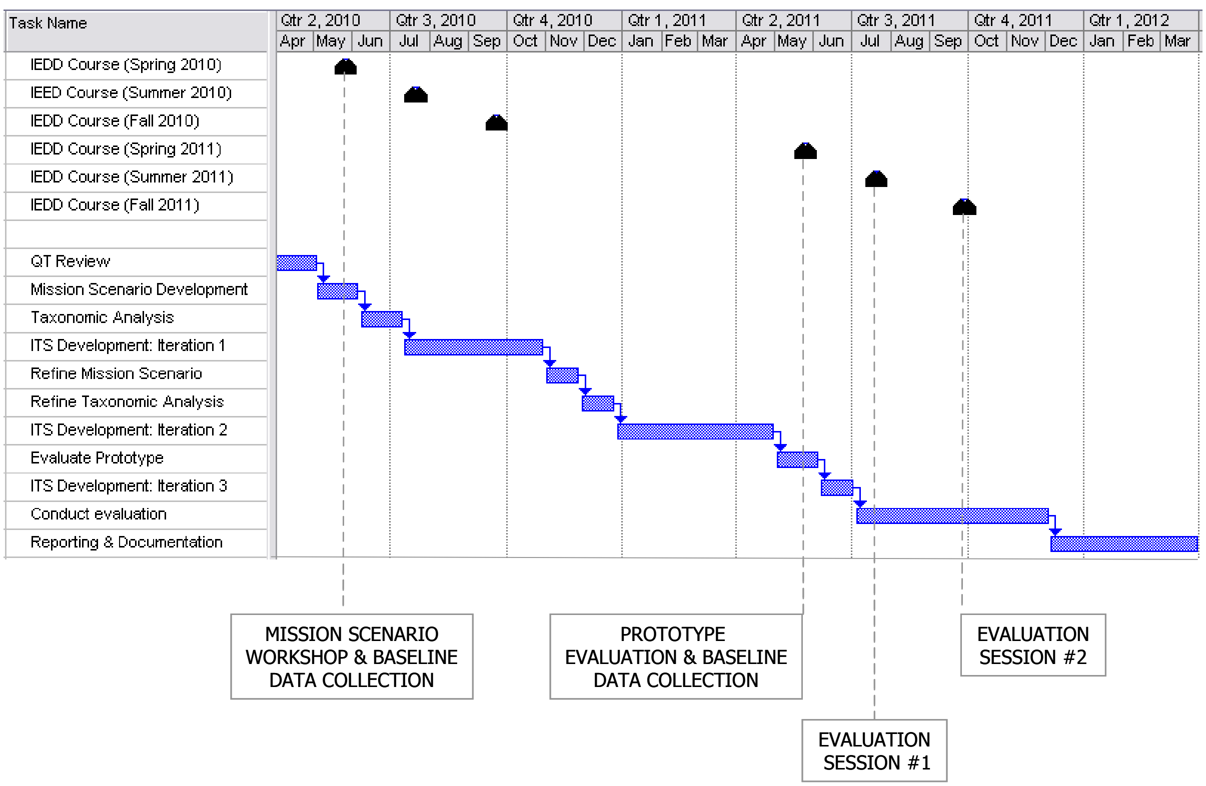


Figure 3-16: Provisional IEDD ITS implementation and evaluation schedule

3.5 Recommended Implementation Plan for the IEDD Mobile Learning ITS

Parallel activities were undertaken to review and identify appropriate mobile devices for adaptive learning and intelligent tutoring technologies (Kramer, Tryan and Banbury, 2010), with the intention of exploring the feasibility of porting content from the IEDD Operator Course ITS on to the mobile device.

At a minimum, the CAE PS development team will exploit any lessons learnt from the development of the ‘PC-based’ IEDD ITS to recommend how adaptive learning and intelligent tutoring technologies can be successfully ported across to the mobile platform. Ideally, the CAE PS team will develop a prototype version of the IEDD ITS on a mobile device; however, this will depend upon the development schedule of the ‘PC-based’ version of the IEDD ITS.

The evaluation of adaptive learning and intelligent tutoring technologies on a mobile learning platform will be limited to an informal evaluation by ITS project team personnel, at a minimum. Ideally, IEDD course students would also take part in the evaluation process; however, their involvement will depend upon the development schedule of the ‘PC-based’ version of the IEDD ITS. There are no plans to formally evaluate (i.e., conduct rigorous experimentation) the mobile version of the IEDD ITS under the auspices of the current project.

4 EVALUATION PLAN

This section of the report describes the evaluation plan for the IEDD Operator Course ITS. The first section describes earlier efforts by Banbury, Roberts, Hartlen and Unrau (2009) to identify the objectives, constraints, and generic experimental design for evaluating a hypothetical example of the IEDD ITS. The second section describes the methodology and approximate schedule for activities pertaining to the evaluation of the IEDD ITS.

4.1 Introduction

Banbury, Roberts, Hartlen and Unrau (2009) presented an overview of issues pertaining to the evaluation of the implementation of the adaptive learning technologies within the IEDD course. These issues relate to the examination of the pedagogical impact of the adaptive learning enhancements on the IEDD course within the context of both self-paced individual learning and instructor-led group learning situations. Their report provides information with regards to the methodological approach suggested for the evaluation. It also comprises a discussion of the participants, experimental design, and measures of effectiveness, and a number of issues for the development of the evaluation methodology. Banbury et al.'s report represents the first step in the development of the IEDD ITS evaluation methodology and the topics discussed within it were based on a number of assumptions and constraints that had been identified at that time.

This section, therefore, provides an update to the evaluation plan presented by Banbury and colleagues. To avoid undue repetition in this report, the reader is advised to refer to both evaluation documents. The evaluation plan and schedule described in the following section is driven by a number of constraints. Specifically:

- The project will be completed by 31st March 2011.
- Baseline Data Collection to coincide with the spring 2010 and spring 2011 IEDD Operator Courses. This provides a total of approximately 40 participants (20 per course).
- IEDD ITS Evaluation to coincide with the summer and fall 2011 IEDD Operator Courses. This provides a total of approximately 40 participants (20 per course).

Both the Baseline Data Collection and IEDD ITS Evaluation phases are described in more detail below. It is important to note that the methodology is likely to evolve as further assumptions and constraints are identified. As such, this section does not represent the final methodology that will be used in the evaluations, but is instead intended to stimulate debate and discussion.

Finally, as discussed in section 2.2.1.2, instructors from the IEDD operator course stated that no control condition in which some students have a 'lesser learning experience' will be acceptable. As such, the direct evaluation of physiological monitoring technologies was not possible given that these likely performance enhancing technologies could not be ‘turned off’ in a control condition.

4.2 Phase I: Baseline Data Collection

In order to evaluate the impact of adaptive learning and intelligent tutoring technologies on the quality of the questioning technique and threat assessment instruction, it is important to collect baseline data prior to the implementation of the IEDD ITS within the course.

The first phase of the evaluation, therefore, comprises Baseline Data Collection activities to be undertaken during the spring 2010 and spring 2011 IEDD Operator Courses. The baseline data collection comprises the following activities:

- Overall Course Performance Assessment;
- Index of Learning Styles (ILS) Questionnaire; and,
- Conscientiousness Personality Trait Questionnaire.

These data collection activities are described in more detail in the following section.

4.2.1 Overall Course Performance Assessment

A quick and effective way of assessing student performance is to use a direct observation methodology known as *behavioural markers*. Behavioural markers refer to a prescribed set of behaviours indicative of some aspect of performance. Typical behaviours are listed in relation to component skills. Some marker systems have been designed to rate operators’ behaviours in response to predetermined scenario events. Typically, researchers produce a list of acceptable behavioural responses to generated events or tasks (e.g., mission analysis, adaptability–flexibility, decision-making, SA, and communication). Behaviours are linked specifically to stimulus events in a scenario (i.e., these are predefined into a set of acceptable behaviours or task responses) and then they are rated as present or absent. The ratings are normally conducted using personnel experienced in the domain (e.g., a course instructor).

TDE OPS TASK CONDUCT

Ref	Arrival Actions @ RV	Yes	Y/B	No
	Brief from OSC/TET			
	What is the Forensics required? (Critical)			
	Where is the evidence (Critical)			
	Site Integrity			
	Hazards Explosive			
	Bio Hazard protocols			
	HAZMAT Protocols			
	Time on Target needed			
	Determined Tactical considerations			

Ref	Questioning Witnesses	Yes	Y/B	No
	Good questioning technique			
	Task Appreciation / TA for Hazards			

Ref	Briefing & Discussion	Yes	Y/B	No
	Briefed task pers			
	Advised OSC & TET appropriately			
	Timely passage of info			
	Maintains Command & Control of task			
	Devised safe, efficient plan			
	Forensic Protocols adhered to by tasked/breifed Pers			
	Concurrent Activity			
	Flexible for TOT			
	Prioritized Evidence collection			
	Collected relevant evidence			

Ref	Crater/Debris Field Exploitation	Yes	Y/B	No
	Effective equipment selected			
	Effective equipment employment			
	Took and Noted relevant Measurements and locations			
	Relevant Pics taken			
	Pics taken in organized sequence			
	Sufficient amount and angles of pics			
	Re-planned, re-briefed?			
	Gathered sufficient measurements			

Ref	Evidence Collection	Yes	Y/B	No
	Effective equipment selected			
	Effective equipment employment			
	Glove protocol			
	Collection done forensically sound			
	Re-planned, re-briefed?			
	Evidence locations noted			
	Biometric collection			
	Evidence mixing/contamination consideration			
	Proper sample sizes taken			

Ref	Evidence marking	Yes	Y/B	No
	Who			
	What			
	When			
	Where			
	Control Number			

CRITICAL

Ref	Forensic Philosophy Followed	Yes	Y/B	No
	Search Teq proper for TOT			
	Changed gloves as req for damage			
	Changed gloves as req for cross contamination			
	Correct container used when shipping			
	Munitions Items IDd correctly			
	Preserve & Collect Relevant Forensic Evidence			

Ref	Safeties	Yes	Y/B	No
	ICP Safety			
	Cordon Safety			
	Protective Equipment			
	HAZMAT			
	BIO			
	Explosives Safety			
	Weapon / equipment safety			
	Revert back to IED Tech if secondary Explosive Hazard found			

	Example	Yes	Y/B	No
	Use a X in one of Yes,Y/B or No	X		
	Not Applicable use a line			

RESULTS

- 1 or more "NO"s in Critical Safeties or IEDD Philosophies results in test failure

- 5 or more "No"s results in test failure

- 2 "Yes But"s equals 1 "No"

- 10 "Yes But"s result in test failure

- Any combination of "Yes But"s or "No"s equal to or greater than 5 "No"s results in test failure

Number of Critical Safeties =	
For Critical Y/B add .5	
Number of "No"s =	
All No's to be calculated Including Critical	
Number of "Yes But"s =	
All Y/B to be calculated Including Critical Y/B	

PASS / FAIL

Figure 4-1: Example of a behavioural marker checklist for the IEDD Operator Course

An example of a behavioural marker checklist is presented in Figure 4-1. The checklist is currently used to assess student performance on the existing IEDD Operator Course and is based on a three-point scoring regimen (i.e., yes / yes but / no). Alternatively, all behavioural marker elements can be rated on a 4-point Likert scale ranging from, for example, 1 (poor), 2 (minimum expectations), 3 (standard), to 4 (outstanding). The use of a Likert scale provides interval-ratio data which allow the use of inferential statistics, such as regression and correlations. The development of the Likert scale for the student assessments will be undertaken with course instructors during the mission scenario workshop to be held during the spring 2010 course. The workshop will explore the means by which the existing evaluation checklist can be further decomposed to capture the nuances of the questioning skills underlying threat assessment. For example, the present evaluation checklist has only two items pertaining to QT and threat assessment.

In addition, the following data will also be collected:

- Overall course pass / failure rate; and,
- Student demographic information such as: time in CF, rank, trade prior to course, and relevant psychometric data collected by the CF during the student's application and enrolment process.

The analysis of the performance assessments will comprise the following activity:

1. *Statistical correlation of student course performance assessment scores with student demographic information*. This analysis will determine if a particular demographic variables increases (or reduces) the learning performance of the course students.

4.2.2 Index of Learning Styles (ILS) Questionnaire

A baseline of learning styles should be assessed using the Felder Solomon Learning Styles Index online questionnaire administered to capture the initial values used to represent the learner's style and to determine what content needs to be developed within the IEDD ITS in order to support the learning styles of the course students. In addition, baseline learning styles data should be compared against the style of current IEDD course teaching styles to see if the areas where students are failing are indeed those which show a mismatch between learning and teaching style, and/or presentation of information. Finally, as suggested as in Tripp and Moore (2007), that IEDD Operator Course instructors themselves should also be assessed with an index of learning styles, and to compare their own styles with those of their students. The goal is that teaching can be improved when teaching styles are better matched with learning styles.

The Index of Learning Styles (ILS) developed by Richard M. Felder and colleagues comprises questions related to four dimensions: Active/Reflective, Sensitive/Intuitive, Sequential/Global and Visual/Verbal. These dimensions are described as follows:

- Active processing (prefers active student participation in groups) or reflective processing (prefers passive student participation by themselves or with one familiar partner);

- Sensing perception (prefers concrete, practical content) or intuitive perception (prefers abstract, conceptual content);

- Visual input (prefers visual presentation) or verbal input (prefers written and spoken presentation); and,

- Sequential understanding (prefer linear thinking) or global understanding (prefer holistic thinking).

Each dimension consists of two categories, and each category has a score ranging from 1 to 11. Scores ranging from 1 to 3 indicate mild or well balanced between the two categories. For scores between 5 and 7, a moderate preference is indicated, which means favouritism for one of the two categories. Scores between 9 and 11 indicate a very strong preference, meaning difficulty with learning where the environment does not support that category. The ILS can be administered on line and the results are emailed back to the participant automatically (e.g., http://www.engr.ncsu.edu/learningstyles/ilsweb.html).

The analysis of the ILS questionnaire results will comprise the following activities:

1. *Statistical correlation of ILS scores with course performance outcome measures*. This analysis will determine if a particular learning style promotes (or reduces) the learning performance of the course students.

2. *Determination of ILS dimensions clusters across all students on the course*. This assessment will be used to determine what content needs to be developed within the IEDD ITS in order to support the learning styles of the course students. This assessment will be performed subjectively by the CAE PS team.

3. *Determination of the compatibility between the learning styles of the student, and the instructional style of the instructor and instructional content of the course* (e.g., predominately text-based materials and so on). This assessment will be used to determine the effectiveness of current approaches to teaching on the IEDD Operator Course. This assessment will be performed subjectively by the CAE PS team.

4.2.3 Conscientiousness Personality Trait Questionnaire

Durso and Dattel (2004) suggest that differences in the ability to maintain Situation Awareness during an air traffic control task are related to differences in personality; specifically the personality trait of *conscientiousness*. Conscientiousness is the trait of being painstaking and careful, and includes the tendency to show self-discipline, act dutifully, and aim for achievement. The trait shows a preference for planned rather than spontaneous behaviour, carefulness, thoroughness, organization, deliberation (the tendency to think carefully before acting), and need for achievement.

Conscientiousness is one of five super-ordinate traits in the “Big Five model” of personality which also consists of extraversion, neuroticism, openness to experience, and agreeableness (Costa and McCrae, 1992). Discussions with representatives of the IEDD Operator Course suggested that students who had previously been Navy Divers were often the strongest students on the course. Given that, from an anecdotal point of view, professional divers need to be conscientious, it is not surprising that students with a background in professional diving would score highly on a personality trait of conscientiousness, and in doing so, show good Situation Awareness acquisition skills (i.e., threat assessment) during the IEDD Operator Course.

In summary, given the cognitive similarities between the general phenomenon of Situation Awareness, and the situation / threat assessment activities undertaken by IEDD operators, we would expect that IEDD Operator Course students that score highly on measures of ‘consciousness’ should also do well on the course.

The Big Five personality questionnaire, which includes the assessment of the sub-ordinate trait of conscientiousness, can be administered on-line and the results are emailed back to the participant automatically (e.g., http://www.outofservice.com/bigfive/).

The analysis of the Big Five questionnaire results will comprise the following activity:

1. *Statistical correlation of conscientiousness trait scores with course performance outcome measures*. This analysis will determine if this dimension of personality promotes (or reduces) the learning effectiveness of the course students.

4.3 Phase II: ITS Evaluation Sessions

In order to complete the evaluation of IEDD ITS on the quality of the questioning technique and threat assessment instruction, the second phase of the evaluation is to collect data following the implementation of the IEDD ITS within the course.

The second phase of the evaluation, therefore, comprises ITS evaluation sessions to be undertaken during the summer 2011 and fall 2011 IEDD Operator Courses. The ITS evaluation sessions comprise the following activities:

- Overall Course Performance Assessment;
- Index of Learning Styles (ILS) Questionnaire;
- Conscientiousness Personality Trait Questionnaire;
- IEDD ITS Usability Questionnaire; and,
- Situation Awareness and Workload questionnaires.

These data collection activities are described in more detail in the following section.

4.3.1 Overall Course Performance Assessment

The evaluation checklist of behavioural markers developed for the baseline data collection phase will be re-administered. Once again, the ratings will be conducted using personnel experienced in the domain (e.g., instructor). In addition, the CAE PS team will conduct de-briefing sessions with the raters to focus on their evaluation of the questioning skills underlying threat assessment. This qualitative feedback often produces key insights with which to interpret the quantitatative data collected using the evaluation checklists.

In addition, the following data will also be collected:

- Overall course pass / failure rate; and,
- Student demographic information such as: time in CF, rank, trade prior to course, and relevant psychometric data collected by the CF during the student's application and enrolment process.

The analysis of the ILS questionnaire results will comprise the following activities:

1. *Statistical comparison between course performance assessment scores collected during the baseline sessions and those collected during the IED ITS evaluation sessions*. This comparison will determine the pedagogical impact of the IEDD ITS; in other words, the effectiveness of the adaptive learning and intelligent tutoring technologies to improve the learning experience of the course students.

2. *Statistical correlation of student course performance assessment scores with student demographic information*. This analysis will determine if a particular demographic variables increases (or reduces) the learning performance of the course students.

3. Statistical comparison of student demographic information. This analysis will determine if a particular demographic variables increases (or reduces) the learning performance of the course students.

4. Determination of the consistency of the demographic profile between students in the baseline data collection sessions and students in the ITS evaluation sessions. This assessment will be performed using inferential statistics whenever possible. The intention of this analysis is to determine whether the demographic composition of the students across the baseline and evaluation sessions remains relatively stable. If so, any statistical differences observed between the baseline and evaluation sessions (point 1 above) cannot be accounted for by these (confounding) variables.

4.3.2 Index of Learning Styles (ILS) Questionnaire

The Index of Learning Styles (ILS) will be re-administered to students in the ITS evaluation sessions. The analysis of the ILS questionnaire results will comprise the following activities:

1. *Statistical correlation of ILS scores with course performance outcome measures*. This analysis will determine if a particular learning style promotes (or reduces) the learning performance of the course students. We would expect this effect (if any) to weaken given that the IEDD ITS provides instruction consistent with the students' learning style.

2. D*etermination of ILS dimensions clusters across all students on the course*. This assessment will be used to determine if the content developed for the IEDD ITS from questionnaire data collected during the baseline data collection sessions matches the learning styles of the students in the ITS evaluation sessions. This assessment will be performed using inferential statistics whenever possible. The intention of this analysis is to determine whether the learning styles of the students across the baseline and evaluation sessions remains relatively stable. If so, any statistical differences observed between student learning performance in the baseline and evaluation sessions cannot be accounted for by this (confounding) variable.

4.3.3 Conscientiousness Personality Trait Questionnaire

The Big Five personality questionnaire will be re-administered to students in the ITS evaluation sessions. The analysis of the Big Five questionnaire results will comprise the following activities:

The analysis of the Big Five questionnaire results will comprise the following activities:

1. *Statistical correlation of conscientiousness trait scores with course performance outcome measures*. This analysis will determine if this dimension of personality promotes (or reduces) the learning performance of the course students. We would expect this effect (if any) to weaken given the IEDD ITS explicitly encourages a rigorous and logical style of threat assessment by explicitly representing the product of threat assessment in real-time using the SMAP.

2. *Determination of the consistency of the conscientiousness trait scores between students in the baseline data collection sessions and students in the ITS evaluation sessions*. This assessment will be performed using inferential statistics whenever possible. The intention of this analysis is to determine whether the personality profile of the students across the baseline and evaluation sessions remains relatively stable. If so, any statistical differences observed between student learning performance in the baseline and evaluation sessions cannot be accounted for by this (confounding) variable.

4.3.4 IEDD ITS Usability Questionnaire

The Technology Acceptance Model (TAM) is an information systems theory that models how operators come to accept and use a technology (Davis, 1989). The model suggests that when operators are presented with a system, a number of factors will influence their decision about how and when they will use it, notably:

- *Perceived Usefulness*. This is defined as ‘the degree to which a person believes that using a particular system would enhance his or her job performance’.

- *Perceived Ease-of-Use*. This is defined as ‘the degree to which a person believes that using a particular system would be free from effort.’

The TAM utilizes a questionnaire that has been assessed for robustness across populations and predictive validity. Studies have found high reliability and good test-retest reliability and have found that the instrument had predictive validity for intent to use, self-reported usage and attitude toward use. The sum of this research has confirmed the validity of the instrument, and supports its use with different populations of operators and different software choices.

This questionnaire will be adapted in order to test the high-level usability aspects of the IEDD ITS GUI (e.g., suitability of screen windows, interaction devices and so on) to assess student perceptions of system ease of use, and the perceived utility of the IEDD ITS functionality and capabilities (e.g., intelligent tutor, SMAP and so on) to assess student perceptions of system usefulness. Ratings will be based on a five-point Likert scale; ranging from 1: Strongly Disagree to 5: Strongly agree. The specific content of this questionnaire will be developed once the IEDD ITS has reached a mature stage in its development and its functionality and capabilities are clearly defined.

4.3.5 Situation Awareness and Workload questionnaires

Situation Awareness (SA) is a key determinant of IED disposal activities and relates to the ability of the IEDD operator to maintain awareness of task-relevant entities in their immediate environment. The measurement of SA within the context of the IEDD ITS evaluation is important given the importance of the appropriate questioning of witnesses, and the subsequent threat assessment that is derived from it. A validated measure of a student's SA following the threat assessment process will help to verify any conclusions we make about the effectiveness of the SMAP tool; essentially, an explicit representation of their SA. There are several well-validated measures of SA that are readily available and applicable to these types of validation. However, the decision over which measure to use will be taken once the IEDD ITS has reached a mature stage in its development and its functionality and capabilities are clearly defined.

Another key determinant of task performance is the workload experienced by the student when conducting their threat assessment within the scenario. Workload can be conceptualised in terms of both physical and mental effort. Workload data provides a useful insight into the task difficulty experienced by the student. This insight allows other conclusions about the student's learning experienced to be interpreted in this light. Once again, there are several well-validated measures of workload that are readily available and applicable to these types of validation. However, the decision over which measure to use will be taken once the IEDD ITS has reached a mature stage in its development and its functionality and capabilities are clearly defined.

5 CONCLUSIONS

The final section of the report summarises the results of the stakeholder analysis, and provides recommendations for the next steps for both the implementation plan and evaluation plan.

5.1 Summary of Results

The results of the stakeholder analysis demonstrate a range of maturing technologies that can be usefully applied to the development of an intelligent tutoring system designed to augment the IEDD Operator Course, as part of the CF e-learning initiative. The recommendations from the stakeholder meetings, and subsequent analysis of the stakeholders themselves, are described below.

5.1.1 Stakeholder Meetings

In summary, the stakeholder meetings were a success insofar as they provided a rich source of information and advice for the implementation of ITS technologies, and an opportunity to establish relationships with the stakeholders of the ITS project. The key outcomes were as follows:

1. The selection of the IEDD Operator Course for implementation of adaptive learning and intelligent tutoring projects is appropriate.

2. The IEDD Operator Course personnel are keen to support the ITS project in terms of access to course materials, instructors and students.

3. In terms of the selection of the appropriate simulation and modeling tools to implement the IEDD Operator Course ITS, the clear consensus was that Second Life was *not* an appropriate environment (as we had first thought), and that Bohemia Interactive's VBS2 should be the tool of choice.

4. DLSE has offered to provide VBS2 support to DRDC (and CAE PS through the ITS contract) in terms of software licences, a smaller terrain map, existing content, and modeling and coding support (through a sub-contract).

5. DRDC Toronto (C-IED TDP) is a key collaborator for the ITS project; both in terms of sharing VBS2 content pertaining to C-IED, and identifying future technology transfer opportunities (e.g., with the CIITE project).

5.1.2 Stakeholder Analysis

The stakeholder analysis determined that the implementation plan and conduct of the project must be cognisant of the roles of stakeholders during the different project phases. Areas for consideration in the detailed implementation plan, organized by project phase, are as follows:

- *Analysis and design phase*. Identify areas where capabilities of stakeholders may provide the ITS with an advantage. During the analysis and design phase, the role of subject matter experts is particularly important and demands a higher level of involvement than during other phases. Communication and buy-in for stakeholders who may provide subject matter knowledge will be key during this phase.

- *Implementation phase*. Identify areas where capabilities of stakeholders may provide the ITS with an advantage. For instance, are their people in stakeholder organizations with the skills or knowledge to do reviews or contribute media content or technologies to the project?

- *Evaluation phase.* Identify appropriate stakeholders to participate in the evaluation of the project outcome, and stakeholders who can create a larger degree of support and information dissemination about the results of the ITS project.

Finally, it is recommended that the project team maintains a ‘technology watch’ throughout the duration of the project. The technology watch will include activities pertaining to:

- Monitoring of virtual world and gaming technologies;

- Monitoring role changes in the stakeholder community;

- Monitoring for new stakeholders;

- Maintaining stakeholder involvement at the right time;

- Communicating project outcomes with stakeholders and receiving any new findings or knowledge of the stakeholders themselves;

- Providing feedback loops as a way to keep stakeholders involved in the project; and,

- Ensuring that project deliverables are visible to the appropriate stakeholder (to be determined on a case-by-case basis).

5.2 Next Steps

It is important to note again that the scope of potential ITS developments under consideration might likely exceed the schedule and budget available to develop a prototype and deploy the prototype into the existing IEDD course schedule to perform experimentation. As such, the project team will analyse the technology and instructional design options available and develop a detailed implementation plan to match the development of the IEDD ITS to the constraints of the project budget and schedule. The work plan described in this report details the work to be performed to produce an ITS prototype to support the evaluation of its utility as a component of the existing IEDD Operator Course. The implementation plan and schedule will continue to evolve over the next phase of the project as more information about the IEDD Operator Course, teaching scenario and instructional design comes to light.

The report recommends a number of tasks to be conducted early during the next phase of the project in order to provide more detailed plans for the implementation of ITS technologies within the IEDD Operator Course:

- Questioning technique literature review;
- Development and validation of the IEDD ITS mission scenario;
- Conduct taxonomic analysis (including instructional design); and,
- IEDD ITS development (iteration 1).

The evaluation plan will also continue to evolve in light of the findings from the taxonomic analysis and the development of the functionality and capabilities of the IEDD ITS itself. The taxonomic analysis will also identify and describe what measures of performance and the tools should be used to evaluate the efficacy of the IEDD ITS to enhance the learning experience of the student. Finally, the CAE PS team will contact the Directorate of Military Personnel Operational Research and Analysis (DMPORA) for ethical approval to collect physiological data from CF personnel during the ITS evaluation sessions. In addition, the CAE PS team will seek guidance from the ITS project’s scientific authority regarding the requirement for ethical approval from DRDC Toronto.

6 REFERENCES

Banbury, S., Gauthier, M., and Scipione, A., (2007). Literature Research of Design Guidelines for Intelligent Adaptive Interfaces and Automation. CAE Professional Services Report to DRDC Toronto.

Banbury, S., Roberts, S., Hartlen, D., and Unrau, D. (2009). A feasibility study of suitable adaptive learning and intelligent tutoring technologies for e-learning environments. CAE Professional Services Report to DRDC Toronto.

Costa, P.T.,Jr. and McCrae, R.R. (1992). Revised NEO Personality Inventory (NEO-PI-R) and NEO Five-Factor Inventory (NEO-FFI) manual. Odessa, FL: Psychological Assessment Resources.

Durso, F.T., and Dattel, A.R. (2003). SPAM: The real-time assessment of SA. In S. Banbury and S. Tremblay (Eds.). A Cognitive Approach to Situation Awareness: Theory and Application. Aldershot, UK: Ashgate and Town.

Endsley, M. (1995). Toward a theory of Situation Awareness in dynamic systems. Human Factors, 37(1), 32-64.

Entwistle, N. J. (1998). Improving teaching through research on student learning. In JJF Forrest (ed.) University teaching: international perspectives. New York: Garland.Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3), 319-340.

Felder, R. M., and Solomon, B. A. (2006). Index of Learning Styles. Retrieved on August 6, 2006, from http://www.engr.ncsu.edu/learningstyles/ilsweb.html

Kramer, C., Tryan, J.L., and Banbury, S. (2010). Literature review on suitable adaptation mechanisms and mobile learning technologies for adaptive learning and intelligent tutoring environments. CAE Professional Services Report to DRDC Toronto.

Pronovost, S., Roberts, S., and Banbury, S. (2008). A Study of Suitable Learning Styles for Adaptive Learning and Intelligent Tutoring Methods. CAE Professional Services Report to DRDC Toronto.

Ross, L., Lepper, M. R., and Hubbard, M. (1975). Perseverance in self-perception and social perception: Biased attribution processes in the debriefing paradigm. Journal of Personality and Social Psychology, 32, 880-892.

Unrau, D., Johnson, J., Bahramifarid, N., Bricio, J. and Oliver J. (2009). Fourth Federation Development Spiral 1: Final Report. CAE Professional Services.

Wason, P. C. (1960). On the failure to eliminate hypotheses in a conceptual task. Quarterly Journal of Experimental Psychology, 12, 129-140.

7 LIST OF ACRONYMS

AAR	After Action Review
AFIILE	Air Force Integrated Information and Learning Environment
ALSC	Army Learning Support Centre
ANA	Afghan National Army
ANP	Afghan National Police
ARP	Applied Research Project
CAMIX	Civilian Modeling Experimentation
CBT	Computer Based Training
CDA	Canadian Defence Academy
CF	Canadian Forces
C-IED	Counter Improvised Explosive Device
CIITE	Counter IED Immersive Training Environment
CO	Commanding Officer
COTS	Commercial-Off-the-Shelf
DLR	Directorate of Land Requirements
DLSE	Directorate of Land Synthetic Environments
DMPORA	Directorate of Military Personnel Operational Research and Analysis
DND	Department of National Defence
DRDC	Defence Research Development Canada
EDR	Electrodermal response
EEG	Electroencephalography
EFIT	Environmental Familiarisation and Indicator Trainer
EW	Electronic Warfare
FPS	First Person Shooter
GOTS	Government Off-the-shelf
GSR	Galvanic Skin Response
GUI	Graphical User Interface
HCI	Human Computer Interaction
HF	Human Factors
HRV	Heart Rate Variability
IAS	Intelligent Adaptive System
IED	Improvised Explosive Device
IEDD	Improvised Explosive Device Disposal
ILS	Index of Learning Styles
ITS	Intelligent Tutoring System
KS	Knowledge Sources
KSA	Knowledge, Skills and Attitudes

LCMS	Learning Content Management Systems
LMS	Learning Management Systems
MTP	Main Teaching Points
NDHQ	National Defence Head Quarters
NPC	Non-Player Characters
NRC	National Research Council
OMI	Operator Machine Interface
OSC	On Scene commander
PGR	Psychogalvanic reflex
P-Learn	Personal learning Environment
PO	Performance Objectives
QRP	Quick Response Personnel
QS	Qualification Standards
QT	Questioning Technique
RSP	Render Safe Procedure
SA	Situation Awareness
SCORM	Sharable Content Object Reference Model
SCR	Skin conductance response
SMAP	Situation Model Argument Map
SME	Subject Matter Expert
TAM	Technology Acceptance Model
TDP	Technology Demonstration Project
UAV	Uninhabited Air Vehicle
US RDECOM	United States Research and Development Engineering Command
VBS2	Virtual Battle Space 2

APPENDIX A STAKEHOLDER ANALYSIS MEETINGS

Table 7-1 describes the meetings that were held as part of the ITS Stakeholder Analysis.

Table 7-1: ITS Stakeholder Analysis meetings

ID #	Visit	Time and Date	Location	Issues Discussed	CAE PS Attendees
1	C-IED Task Force / Training, NDHQ (Maj Dan Schurman) T: 613 992 2330 M: 613 513 9104 DAN.SCHURMAN@forces.gc.ca	1100, 22nd January 2010	NDHQ, Ottawa	Content, courses taught, training needs analysis. Relationship with other IED / e-learning initiatives at CFB Gagetown. Emphasis on IEDD Operator Course.	SB, KO and CK
2	C-IED Defeat the Device Center of Excellence, CF School of Military Engineering (Capt Luc-Frederic Gilbert) T: 506 422 2000 ext. 7212 Luc-Frederic.Gilbert @ forces.gc.ca	0900, 25th January 2010	Building J-10 (CFSME), Room B209.CFB Gagetown, Fredricton NB	Tools, approaches, content, courses taught, training needs analysis. Relationship with other IED / e-learning initiatives at CFB Gagetown. Emphasis on IEDD Operator Course.	SB and KO
3	C-IED Attack the Network, Combat Training Centre (Maj Andrew Gimby) T: 506 422 2000 ext. 2654 Andrew.Gimby@ forces.gc.ca	1400, 25th January 2010	Tactics School, CFB Gagetown, Fredricton NB	Tools, approaches, content, courses taught, training needs analysis. Relationship with other IED / e-learning initiatives at CFB Gagetown.	SB and KO
4	Learning and Collaborative Technologies Group, National Research Council of Canada, Institute for Information Technology (Dr Rodrigue Savoie) T: 506 861 0951 Rodrigue.Savoie@nrc-cnrc.gc.ca	0930, 26th January 2010	NRC, University of New Brunswick, Fredricton NB	Tools, approaches. Discuss CDA collaboration and relationship. Sub-contract review and progress. Mobile learning literature discussion.	SB and KO

ID #	Visit	Time and Date	Location	Issues Discussed	CAE PS Attendees
5	Directorate of Land Synthetic Environments (Capt Chris Taff and Dr Paul Roman) CHRIS.TAFF@ forces.gc.ca T: 613 541 5010 ext 5042 PAUL.ROMAN@forces.gc.ca	1300, 11th February 2010	Directorate of Land Synthetic Environments, CFB Kingston ON	Content, tools used, lessons learnt. Relationship with other IED / e-learning initiatives at CFB Gagetown.	SB, KO and CK
5	Directorate of Learning Innovation, Canadian Defence Academy (LCdr Remi Tremblay) T: 613 541 5010 ext 3938 Remi.Tremblay@forces.gc.ca	0930, 12th February 2010	Canadian Defence Academy, CFB Kingston ON	Tools, approaches, and lessons learnt. Discuss CDA collaboration and relationship. Relationship with other IED / e-learning initiatives at CFB Gagetown and elsewhere.	SB, KO and CK
6	Counter-IED TDP, Collaborative Performance and Learning Section, DRDC Toronto (Dr Jerzy.Jarmasz and Sgt Dorothy Wojtarowicz) T: 416 635 2000 ext 3081 Jerzy.Jarmasz@drdc-rddc.gc.ca	1100, 24th February 2010	DRDC Toronto, 1133 Sheppard Ave West, Toronto ON	Content, tools used, lessons learnt. Relationship with other IED / e-learning initiatives at CFB Gagetown and elsewhere.	SB and CK

APPENDIX B STAKEHOLDER ANALYSIS RESULTS

Table 7-2 describes the results of the ITS Stakeholder Analysis.

Table 7-2: ITS Stakeholder Analysis results

Stakeholder Organisation	Stakeholder Name	Role	Stake / Interest in Project	ITS Related Programs and Links	ITS Related Capabilities	Map to Program Phase	Stakeholder Needs	Perceived Attitude and Risks	Project Impact on Stakeholder	Connections to Other Stakeholders
C-IED Task Force DND Ottawa, ON	Maj. Dan Schurman NDHQ, Ottawa, ON	Training Development Officer. Lead on communications with other C-IED stakeholders.	High stake and interest. High influence. Ongoing interest in applications of project to other training needs.	Involved in previous DRDC studies. Current project: Analysis of selection process of IEDD operators.	Access to Subject Matter Experts. Access to training documentation.	Analysis and Design. Implementation. Evaluation.	Communication. Information Provision. Team member. Advice and Support.	Highly supportive. Key stakeholder desiring to effect change through technologies. Low Risk.	High. Will provide a tools/approach that can be used elsewhere in the Army training requirements.	Direct Support: Defeat the Device Centre of Excellence, School of Mil. Eng. Direct Support: C-IED Attack the Network, Combat Training Centre. Direct: DLR is part of C-IED Task Force. Desire improved connection to Army Sim Centre.
C-IED Defeat the Device Centre of Excellence School of Military Engineering IEED Operator Course Gagetown, NB	Capt. Gilbert Gagetown, NB	Point of Contact for IEED Operator Course.	High stake and interest. High influence. Ongoing interest in applications of project to other training needs. High Power. High Need.	Linked to other IED courses and training requirements.	Subject Matter Experts Training design and content owner.	Analysis and Design. Implementation. Evaluation.	Communication. Information Provision. Team member. Advice and Support. Manage expectations for scope and timelines.	Highly supportive. Key stakeholder interested in ensuring best learning experience for all students. Low Risk.	High impact for team and course responsibilities.	Direct Support: C-IED Task Force. Direct Support: C-IED Attack the Network, Combat Training Centre. Indirect: Combat Training Centre provides media / training support as needed. Awareness: DLR is part of C-IED Task Force. Awareness: DRDC Toronto C-IED Projects.
Combat Training Centre Army Training Gagetown, NB	Maj. Gimby Gagetown, NB	Point of Contact for Combat Training Centre.	Medium stake and interest. Ongoing interest in applications of project to other training needs. Low Power. Low Need.	Linked to wide range of courses and training requirements.	Knowledge of and links to other courses. Knowledge of media produced for other courses.	Analysis and Design. Implementation. Evaluation.	Awareness of progress.	Supportive.	Low impact.	Direct Support: DRDC (Toronto) C-IED projects. Direct Support: Army Learning Support Centre (ALSC) Indirect: CF School off Communiations and Electronics work in C-IED and RC Defeat the Device. Indirect: School of Military Intelligence (Kingston), Tactical Questioning Course (for intelligence staff). POC Maj. J.P. Terfy. Indirect: Defeat the Device COE, EW perspective.
National Rearch Council (NRC) IIT Branch Fredericton, NB	Rod Savoie Moncton, NB	Group Leader Learning and Collaborative Technologies IIT, NRC	High stake and interest. CAE PS Subcontractor. Parrallel research interests on behalf Government of Canada.	Consulting on Personal Learning Environments to CDA. Cognitive modelling (Bruno Emund). Adaptive Learnining System (Doctor-Patient Example, Bruce Spencer).	Subcontractor for speciality skills in Mobile Learning and Adaptive Learning.	Analysis and Design. Implementation. Evaluation.	Communication. Information Provision. Team member. Advice and Support.	Highly supportive. Key stakeholder desiring to effect change through technologies. Low Risk.	Medium. Achieves mandate to work with other government departments and industry.	Direct Support: Army Learning Support Centre (ALSC). Direct Support: Various project with Canadian Defence Academy (CDA).

Stakeholder Organisation	Stakeholder Name	Role	Stake / Interest in Project	ITS Related Programs and Links	ITS Related Capabilities	Map to Program Phase	Stakeholder Needs	Perceived Attitude and Risks	Project Impact on Stakeholder	Connections to Other Stakeholders
Canadian Defence Academy. Concept Development and Exploration. Kingston, ON	LCdr. (Navy) Remi Tremblay Kingston, ON	Concept Development and Exploration.	Medium stake and interest. Ongoing interest in applications of project to other CF wide training needs. Medium Power. Medium Need.	Work in Domains: 1) Future learning concepts and architectures (PLEARN) 2) Simulation: Virtual World and Gaming exploration (CASE Contract, SIMON project) 3) Mobile: Track use, previous lit review. 4) Physical: Biofeedback, Technology Watch. 5) Cognitive Task Analysis: Visualized decision paths.	Knowledge of and links to other courses. Knowledge of media produced for other courses. Exploration and Lessons Learned with variety of gaming and virtual world technology.	High Level Awareness: Analysis and Design. Implementation. Evaluation.	Communication. Information Provision. Team member. Advice and Support.	Highly supportive. Key stakeholder desiring to effect change through technologies. Low Risk.	Medium. Achieves mandate through co-operation and awareness.	Direct Support: Army, Navy, Airforce Training Organizations Direct Support and Awareness: DRDCs Awareness: Adhoc projects.
Directorate Land Synthetic Environment (DLSE) and Director Land Requirements (DLR) Kingston, ON	POC: Capt. Chris Taff Second POC: Dr. Paul Roman	Technology support for Army simulation and training.	Low stake. High interest. Ongoing interest in applications of project to other training needs.	Use of some common game or virtual world technology. Developed Ngrain models for 300 mine types. Deployed on mobile device to assist in recognition. Knowledge of pros and cons of technologies. Knowledge of related programs.	Limited VBS 2 development capability through subcontractors. Source of technology lessons learned.	Implementation	Awareness of progress.	Highly supportive. High Interest. Key stakeholder desiring to effect change through technologies. Low Risk.	Low impact.	Direct: Army simulation use of VBS and other technologies. Indirect: Knowledge of many other CF programs. Indirect: Links to Combat Training Centre and ALSE (Gagetown, NB).
DRDC (Atlantic) HLA Centre of Excellence. Dartmouth, NS.	Brad Dillman DRDC (Atlantic) Software Lead Dartmouth, NS.	Exploration with game and virtual world technology to support partners. Links to HLA centre of excellence.	Medium stake and interest. Ongoing interest in applications of project to other DRDC initiatives.	VBS 2 Modelling of Halifax harbour. VW technology to simulate virtual operations room.	Limited VBS 2 development capability through subcontractors. Source of lessons learned for Second Life in non-training applications.	N/A	Awareness of progress.	Highly supportive. High Interest. Key stakeholder desiring to effect change through technologies. Low Risk.	Low impact.	Direct Support: DRDC (Toronto)
DRDC IED TDP Toronto, ON	Jerzy Jamasz Toronto, ON	DRDC Lead IED Technology Demonstration Project	Low stake. High interest. Ongoing interest in applications of project to other training needs.	IED TDP has some overlapping stakeholders and high level objectives.	Domain knowledge and interest. Lessons learned in VW technology.	Analysis and Design. Implementation. Evaluation.	Communication. Information Provision. Advice and Support.	Highly supportive. High Interest. Key stakeholder desiring to effect change through technologies. Low Risk.	Low impact.	All.

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(U) This document presents the results of a Stakeholder Analysis of Canadian Forces (CF) Counter Improvised Explosive Device (IED) training courses. The Stakeholder Analysis was used to inform the design, development and evaluation of an Intelligent Tutoring System (ITS) for the IED Disposal (IEDD) Operator Course. This work was conducted under Contract W7711−09−8153/001/TOR “Intelligent Tutoring for Distance Learning” for Defence Research Development Canada (DRDC) Toronto by CAE Professional Services (CAE PS).

One of the most challenging activities for a distance education facilitator is to be responsive to student needs and customize the learning experience to the student’s individual learning style, help socialize the student to the institution, and keep the learner engaged in spite of the isolated environment. To achieve these goals, Defence Research and Development Canada (DRDC) – Toronto has initiated an Applied Research Project (ARP) to investigate mechanisms to improve efficiency and effectiveness for the Canadian Forces (CF) distance learning capability.

In order to support these goals, a Requirement and Stakeholder Analysis for the CF Counter−IED Training Courses was undertaken by CAE PS to investigate the requirements of stakeholders of the CF IEDD Operator Course for the development of adaptive learning technology integration and validation plans. Given the high failure rate in the existing IEDD Operator Course, problematic aspects of the course was one of the foci of the Stakeholder Analysis. The discussion with stakeholders focused, in part, on the feasibility of demonstrating the capability of intelligent tutoring technology within the IEDD Operator Course.

The report presents the results of the Stakeholder Analysis interviews conducted between the 22nd January 2010 and the 23rd February 2010, and describes the recommendations for implementing adaptive learning and intelligent tutoring technologies into a suitable CF distance−learning course. Following this, the report describes the implementation plan for the IEDD Operator Course ITS, in terms of its content and capabilities, and describes the notional architecture of the IEDD ITS in more detail, as well as the schedule for the design, implementation and evaluation of the ITS. Finally, the report describes the evaluation plan for the IEDD Operator Course ITS in terms of the methodology and approximate schedule for activities pertaining to the evaluation of the ITS.

The report also recommends a number of tasks to be conducted early during the next phase of the project in order to provide more detailed plans for the implementation of ITS technologies within the IEDD Operator Course:

• Questioning technique literature review
• Development and validation of the IEDD ITS mission scenario
• Conduct taxonomic analysis (including instructional design); and,
• IEDD ITS development (iteration 1).

(U) L’une des tâches les plus difficiles qui incombe à l’instructeur à distance est de répondre aux besoins de l’apprenant et de personnaliser l’acquisition de connaissances en fonction du style d’apprentissage du stagiaire, d’entretenir la relation entre le stagiaire et l’établissement de formation et de conserver la motivation de l’apprenant malgré son isolement. Pour y parvenir, il faut examiner des moyens d’améliorer la rentabilité et l’efficacité de la capacité d’apprentissage à distance des Forces canadiennes (FC). Dans cette optique, on a entrepris une Analyse des besoins et des intervenants des cours d’instruction des FC sur la neutralisation des IED afin de connaître les besoins des

intervenants du cours d’opérateur de neutralisation des engins explosifs improvisés (IEDD) des FC en matière d’intégration et de validation de technologies d’apprentissage adaptatif. Vu le taux élevé d’échec au cours actuel d’opérateur IEDD, les aspects problématiques du cours ont été ciblés durant l’Analyse des intervenants. Les échanges avec les intervenants ont porté entre autres sur la faisabilité de la démonstration de la capacité de la technologie des tutoriels intelligents dans le cadre du cours d’opérateur IEDD. Le rapport présente les résultats des entrevues réalisées aux fins de l’Analyse des intervenants et recommande le plan de mise en oeuvre du système tutoriel intelligent (ITS) du cours d’opérateur IEDD, plus précisément son contenu et ses capacités, et explique plus en détail l’architecture théorique du tutoriel IEDD. On recommande aussi dans le rapport le plan d’évaluation du système tutoriel intelligent du cours d’opérateur IEDD, des points de vue de la méthodologie et du calendrier approximatif des activités touchant l’évaluation du ITS.

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